# On GELIDIUM and PTEROCLADIA of Japan

Pls. 16–33

Prof. Dr. K. Okamura

(Received Jan. 10, 1934)

## Introductory Remarks

Within the boundary of our country there are many species of *Gelidium*. Hitherto, however, few were described and many remained undetermined, most of which pass under the current name of *G. Amansii*. Having been interested in Gardner's "American New Species of Gelidium," the writer entered into a revisional study of *Gelidium* and added five new species and 5 new forms to our flora, at the same time, fully recognizing the species already reported by foreign authors such as *G. linoides*, *G. Amansii* and *G. elegans*. The already known Japanese species are *G. divaricatum* Mart., *G. pacificum* Okam., *G. japonicum* (Harv.) Okam., *G. subcostatum* Okam., *G. crinale* (Turn.) Lmx. and *G. pusillum* (Stackh.) Le Jol.

Before proceeding further, it will not be unnecessary to give some remarks on distinguishing *Gelidium* from *Pterocladia*. It is self evident in the case when there are cystocarps; but in sterile state it is often difficult to separate one from the other, at least in the case of our flora, though there are some differences in external appearance. For instance Howe[1] considers *Pterocladia* of the Cowdry's list from Pei-tai-ho (which the writer[2] has identified to be *Pterocladia*) to be *Gelidium*, saying "We find no reason for believing them (specimens) to belong to *Pterocladia* rather than to *Gelidium*."

In the course of the study the writer came to the conclusion that in sterile state *Gelidium* is distinguished from *Pterocladia* by the difference of the arrangement of rhizoidal filaments. In the former, they are, as a rule, thickly congested on the external side of the central tissue and in that tissue few are scattered in younger parts of frond, becoming gradually denser as the part grows in age. On the contrary, in *Pterocladia* rhizoidal fila-

1) Howe, M. A. Chinese Marine Algae, 1924, p. 138.

2) Cowdry, N. H. Plants from Pei-tai-ho (Journ. N. China Branch of Roy. Asiatic Soc. Vol. LIII, p. 181, 1922).

ments are seen in the central tissue only, either densely or scatteringly. In both genera it is common to find a dense mass of rhizoids on both sides of branches, so that the cross section of branches shows densely congested rhizoids at both corners.

The mode of arrangements of rhizoidal filaments said above, however, is not without some exceptional cases; for instance, as in *Gelidium vagum* Okam. n. sp. and *G. pusillum*. In them some sections show a dense mass of rhizoids in the central tissue, especially in flattened and broader portion, but in other parts, especially in filiform or subcylindrical pedicel-like portion the arrangement is made in a manner as said above.

In the next place, the form of cells of the central tissue is somewhat different in both genera. In *Gelidium*, cells are mostly roundish or transversely elliptical in cross section, and when there are few rhizoids, they are always roundish with some intercellular spaces, while in *Pterocladia*, they are more or less angular like parenchymatic cells with wide calibres, and thinner walls, and closely packed together when there are few rhizoids.

In fructified fronds, cystocarps and tetrasporic sori have some differences between the two genera. The cystocarp of *Gelidium* has a minute carpostome on the median line of pericarp at the center or a little toward the apex. In *Pterocladia* carpostome is elevated more or less like a beak with a large and round opening, situated either vertically or a little obliquely toward the apex a little ahead the middle of the median line. The tetrasporic sori of *Gelidium* are either elongated or elliptical on the apical portion of mostly narrow-linear ramuli, or sometimes oval or obovate in a little broader ones; in any case, sori are strictly limited, that is, have a sharply defined boundary. On the contrary, in *Pterocladia* tetrasporic sori in narrow ramuli are sometimes like those of *Gelidium* but more usually they become widened and have unlimited demarcation. Sorus of a ramulus comes in confluence with sori of lateral ramelli or two or three are formed in a longitudinal row at short intervals in one and the same ramulus.

So far the difference of structure of the frond. On making study of the structure of the frond, I took, for the sake of comparison, the sterile fronds of *Pterocladia lucida*, and *P. capillaris*, and the study of cystocarps and tetrasporic sori have been done in our native plants.

With respect to the determination of the species of *Gelidium* and *Pterocladia* the mode of branching, external habit and structure of frond are of great importance. As stated above rhizoidal filaments are generally congested along both sides of frond. Younger portion of branches has a

few rhizoids in the central tissue, gradually increasing as the part grows in age.

This survey owes much to the directors of the following institutions, whose kindness in allowing examination of *Gelidium* collections is most highly appreciated: Yendo's herbarium in the Botanical Department of Tokyo Imperial University, Fisheries Institute of Hokkaido, Fisheries Experimental Stations of Hokkaido, Wakayama, and Nagasaki. For special collections acknowledgements are gratefully made to Prof. Yamada, Messrs. Ohno, S. Tago, Yoshi K. Okada, and Narita.

### Key to the Japanese Species of GELIDIUM

1. Frond not exceeding 5–6 cm. in height. 2
   Frond more than 5–6 cm. in height. 4
2. Loosely and irregularly branched. *G. crinale* (Turn.) Lmx.
   Densely branched. 3
3. Ramuli regularly pinnate and frond repent or decumbent. *G. divaricatum* Martens
   Ramuli more or less irregularly pinnate, or almost none and the frond repenting or standing from creeping portion. *G. pusillum* (Stackh.) Le Jol.
4. Median line of the main branches evidently thickened (at least in the lower portion) like midrib. 5
   Frond not as above. 6
5. Regularly pinnate, large, and broad as far as 3 mm. *G. subcostatum* Okam.
   Irregularly branched and densely proliferated with congested pinnate branchlets both from margins and surfaces. *G. japonicum* (Harv.) Okam.
6. Frond flat. 7
   Frond ancipito-compressed or sometimes subterete. 8
7. Frond decumbent(?) *G. decumbensum* sp. n.
   Frond erect. *G. tenue* sp. n.
8. Branches obtuse at apex. *G. clavatum* sp. n.
   Branches spinescent at apex. 9
9. Fertile ramuli stands closely together. *G. pacificum* Okam.
   Fertile ramuli scattered. 10
10. Frond remotely and irregularly branched. *G. linoides* Kütz.

Frond not remotely branched, more or less pinnate. 11

11. Fertile ramuli fine and small with short pedicels elegantly arranged along branches near to each other. *G. vagum* sp. n.

Fertile ramuli not fine and more or less long-pedicelled. 12

12. Main branches slightly swollen beneath sharp apex and sterile ramuli near the apex of branches often teeth-like. *G. subfastigiatum* sp. n.

Main branches not swollen beneath apex and all ramuli not teeth-like but spinescent. *G. Amansii* LMX.

*Gelidium divaricatum* MART. Pl. 16, fig. 1–2.

MARTENS Preus. Exped. p. 30, t, 8, f. 4; OKAM. Illustr. Mar. Alg. Japan, Vol. I, n. 1, 1900, p. 5, pl. II; Id. Alg. Japon. Exsic., Fasc. I, no. 4.

Fronds small and dwarf, densely matted, creeping and decumbent, cartilaginous, filiform or tereti-compressed, divaricately branched with short and densely pinnate, opposite or alternate ramuli, acute or blunt at apex, bearing roundish sorus and globular cystocarp on the apex of ramuli.

Hab.: On rocks, barnacles, molluscs etc. near high tide; from Taiwan to Prov. Rikuzen.

Distr.: Tschifu, Hongkong.

*Gelidium crinale* (TURN.) LMX. Pl. 16, fig. 3.

J. AG. Epicr. p. 546; OKAM. Icon. Japan. Alg. Vol. III, p. 195, pl. 146, f. 1–10.

Fronds filiform, teteti-compressed, rising from creeping segments rarely short and simple, usually branched upward from subnaked base in irregular pinnate manner, alternate or opposite, patent, here and there with 2–3 sometimes 4 or more branches rising from same place, acute at apex, 4–5 cm. high, 200–500 $\mu$ thick; tetraspores collected in lanceolate or slightly expanded portion beneath apex of branches.

Hab.: On stones in sandy beach below low tide in calm waters. Ohno and Furumi (Prov. Owari, S. NARITA), Gamogori (Prov. Mikawa).

Distr.: The Mediterranean and Adriatic, The Atlantic, Red Sea.

*Gelidium pusillum* (STACKH.) LE JOL. Pl. 17, fig. 1–2; Pl. 31, fig. 1–2.

*G. pusillum* LE JOL. Liste Alg. Mar. Cherb., p. 139; OKAM. List. Mar. Alg. Caroline and Austr. (Bot. Mag. Tokyo, XVIII, 1904, p. 86–87); Id. Icon. Japan. Alg. Vol. II. p. 11, pl. 54, f. 10–14. *G. repens* OKAM. Contr. Knowl. Japan. Alg. III, p. 7, pl. 1, f. 5–8 (Bot. Mag. Tokyo, XIII,

p. 8) ; Id. Alg. Japon. Exsic. Fasc. I, no. 5.

Hab.: On stones, rocks, etc. near high tide, widely distributed.

f. *foliaceum* n. f. Pl. 17, fig. 3–4.

Fronds minute and dwarf, gregarious, foliaceous, simple, subfasciculately arising in rosette-like clusters from creeping stolon, each ovato-oblong or ovato-lanceolate, very shortly pedicelled, uneven at margins, 3–7 mm high, 1–2 mm broad, blunt at apex. Sterile.

Hab.: On barnacles; Shisô-dima, Seto, Prov. Kii.

The cross section of the flat, leaf-like portion shows dense rhizoids in the central tissue as is the case with *Pterocladia densa* sp. nov., but in the filiform pedicel the central part is void of filaments, leaving narrow intercellular spaces, and rhizoids are found along the external side of the central tissue.

Var. *conchicola* Picc. et Grun. Pl. 17, fig. 5–6.

De Toni Syll. Alg. IV, p. 147; Okam. List. Mar. Alg. Caroline and Mariana Isl., 1915, p. 9, f. 4–9 (Bot. Mag. Tokyo. XXX. 1916) ; Id. Icon. Japan. Alg. VI, p. 42, pl. 273, f. 7–10.

Hab.: On stone; Isl. Hatydyo, Wagu (Prov. Shima).

Distr.: Yap (on shell), Red Sea.

*Gelidium pacificum* Okam. Pl. 16, fig. 4–6.

Okam. Icon. Japan. Alg., III, 1914, p. 99, pl. 126–127, f. 9–11.

Frond large and robust, linear, ancipito-compressed, 3–4 times pinnately branched in an alternate or opposite manner, 30 cm long or more. Branches elongated, patent, slightly flexuose, with ramuli carrying closely decompound pinnate ramelli, 2–2.5 mm broad. Cystocarps swollen beneath the apices of ramuli and ramelli, either terminated with simple or branched, pointed or blunt apices. Tetrasporangia forming sorus in roundish or more less expanded ramuli or remelli.

Hab.: On rocks in the depths of 3–11 fathoms. Miyake-dima, Hatidyo-dima, Kôdu-shima; Prov. Kadusa, Bosyu and Idzu. Fruits in summer.

In the cross section of frond rhizoidal filaments are very dense in the infra-cortical layer and more loose in the central tissue. Inner cells are unequal in size. Structure is just like *Gelidium Amansii* Lmx.

In Yendo's herbarium there are three pieces of frond bearing specific name of *G. polycladum* from Reinbold's herbarium which were collected in Japan. The pieces are only upper portions of branches, each measuring

2–3 cm. in length and with few ramuli bearing cystocarps. They seem most probably to be *G. pacificum*.

*Gelidium subcostatum* OKAM. Pl. 18, fig. 1.

OKAM. in SCHMITZ's Neue japanische Florideen von K. OKAM. (Hedwigia, Bd. XXXIII, 1894), p. 1, taf. X; OKAM. Icon. Japan. Alg. I, p. 233, pl. 46.

Frond broadly linear, ancipito-compressed, 3–4 times distichously pinnate, alternate and opposite, with main branches distinctly midribbed; branches patent on round axils, elongated, elegantly clothed with deltoid teeth-like ramuli which develop to normal branches, 15–35 cm, rarely a half meter, high, and 2–5 mm broad. Tetraspores in ciliform, simple or branching ramuli. Cystocarps ovate, swollen beneath the apex of ramuli. Frond consists of four layers of cells: the medullary layer, of roundish cells of unequal size (mostly narrower), usually 14 $\mu$ up to 23 $\mu$ in diam.; next to that layer there is a parenchymatic tissue consisting of isodiametrical cells of wide calibres, void of rhizoids; outside this layer comes infra-cortical layer consisting of smaller coloured cells densely congested with rhizoids; and finally one-cell-thick, epidermal layer.

Hab.: On rocks in deep waters as deep as 15 fath. or more: from Prov. Satsuma to Prov. Bosyu.

*Gelidium japonicum* (HARV.) OKAM. Pl. 18, fig. 2.

OKAM. Illustr. Mar. Alg. Japan Vol. I, n. 5 (1901), p. 57, pl. 21, Alg. Japon. Exsic. n. 6. *Suhria japonica* HARV. Alg. Wright., n. 26; *Porphyroglossum japonicum* (HARV.) SCHMITZ Neue japan. Florid. (1894), p. 7.

Fronds broadly linear, ancipito-compressed, midribbed, irregularly branching in pinnate manner or parted, more or less densely proliferated from margins and surfaces with short 2–3 times, decompound, pinnate ramuli, 4–20 cm long, 1.5–2 mm broad. Fruits of both kinds produced on the apical part of pinnulae of proliferated pinnae. Cystocarps roundish ovate, blunt or shortly pointed. Tetraspores collected in slightly dilated pinnulae.

Hab.: On rocks and stones extending from midtide to 10–15 fath.; very common along the Pacific coast from Taiwan to Prov. Hitati and from Prov. Nagato to Tadima in the Japan Sea.

*Gelidium Amansii* LMX. Pl. 19–22, pl. 31, fig. 3–7.

KÜTZ. Tab. Phyc. XVIII (1868), p. 16, t. 44; OKAM. Icon. Japan. Alg. Vol. III, p. 25, t. 106; *G. elegans* KÜTZ. l. c. XVIII, p. 18, tab. 52,

f. c-d; *Fucus Amansii* Lmx. Dissert., 1805, p. 48, Tab. XXVI.

Fronds caespitose, often forming very dense tuft, filiform or narrow-linear, ancipito-compressed at least in the lower portion, pinnately branched in 4–5 orders. In early state of growth, frond is more or less regularly pinnate making pyramidal outline, especially so in f. *typica* and f. *elegans*. This condition is rarely kept long, and branches arise pinnately from very base, but usually it is not kept till the plant reaches adult state, and soon the upper part elongates to main branches leaving the basal portion wasted. Branches are more or less flexuose, but in some quite straight, patent, pinnated with ramuli, longer or shorter mixed without any order, the former remaining simple or becoming compound. All the branches end in sharp and acute apices, and the plant attains 10–30 cm in height, and 0.5–2 mm in breadth. Those growing in shallow water are shorter and more irregular in ramification with branches arising near to each other, while those in deeper waters are longer and remotely branched. The lower portions of frond are always ancipito-compressed, with the thickness of 230–530 $\mu$, but upper ones often subterete. Tetrasporic ramuli are elongato-ovate or oblong-spathulate, the narrower ones tapering gradually to pedicel, while the broader ones abruptly, and their form and breadth vary in some measures. Sometimes branches having fertile ramuli are elegantly 2–3 times pinnate with ramuli of equal length, while in others fertile ramuli and branches, which bear fructified ramuli in turn, arise without any order. Cystocarps swollen beneath the apex of ramuli, terminated with simple or branched apical segments.

Cells of the central tissue are not uniform in size, larger ones measuring 25–30 $\mu$ in diameter, more or less leaving intercellular spaces in the younger parts, usually with rhizoidal filaments, which are densely congested outside the central tissues. Rhizoids are more numerous in the thicker portion of branches. Size, thickness, and habit of fronds vary very much according to localities. The substance is rather rigid, cartiliginous, and harsh to touch, but those growing in calm and protected places or in deeper waters are softer, slenderer, and longer than those in shallower waters.

Hab.: Growing on rocks and stones extending from between tide marks to 13–18 fathoms. Very widely distributed within the country from Kyushu to the western coast of Hokkaido both on Pacific side and in the Japan Sea; not found on the eastern coast of Hokkaido.

The present plant much varies in size, substance, mode of branching and

external habit according to localities. If one compares the forms standing near the two extremities one will find a marked difference between them, but there are many intermediate forms and it is very difficult to distinguish one from the other.

*Gelidium Amansii* LMX. is characterised by having sharp ramuli, longer and shorter mixed, the former remaining simple or becoming compound. There are, however, fronds elegantly pinnated in 2–3 orders with ramuli of almost equal length. KÜTZING illustrated such a plant with the name of *Gelidium elegans* (KÜTZ. Tav. Phyc. XVIII, p. 18, tab. 52, f. c-d) from the material got at Yokohama by VON MARTENS. This form is not limited at Yokohama, but widely found in other localities and there are many fronds having intermediate characters of *G. elegans* and *G. Amansii*. Thus, there being no fully established character to distinguish *G. elegans* from *G. Amansii*, the writer reduced the former to a form of *G. Amansii* LMX. *G. Amansii* illustrated in my Icones Vol. III, p. 25, pl. CVI, f. 1 presents *G. elegans* KÜTZ.

Many related species hitherto passed among us by the name of *Gelidium Amansii* LMX. Now the writer defines *G. Amansii* LMX. with the diagnosis mentioned below, as the descriptions given in KÜTZ. Sp. Alg. p. 766 as well as in LAMOUROUX's Dissertation p. 48 are very brief and insufficient. The writer formerly thought *G. Amansii* LMX. to be the same with *G. Amansii* LMX. distributed in COLLINS, HOLDEN etc. Phyc. Bor. Am. (Exsic.) n. 585. The latter plant was, however, established by GARDNER as a new species, *G. pyramidale* (GARDN. Gelid. p. 274, pl. 36 and 45, pl. 37, f. 1, pl. 46, f. 2). We know nothing about any referrable specimens of *Fucus Amansii* LMX. except the descriptions and illustrations given in the Dissertation and consider the species illustrated in KÜTZ. Tav. Phyc. XVIII, tab. 44, to be LAMOUROUX's *Fucus Amansii*. The plant in question differs from *G. pyramidale* GARDN. (*G. Amansii* LMX.; COLLINS, HOLDEN etc. Phyc. Bor. Amer. Exsic. n. 585) by the mode of ramification and by not having constricted base of branches.

By the way the writer wishes to make a remark on *Gelidium australe* J. AG. identified by COTTON. There are four specimens having that name in YENDO's Herbarium kept in Tokyo Imperial University which were brought home by that author; two of them from Corea, identified by COTTON,[1] having Kew Garden's label with hand writings of that author; the next

1) To me, *Gelidium australe* J. AG. enlisted in COTTEN's Mar. Alg. from Corea (Kew Bull. 1906) seems most probably to have been based on those material.

from Port Phillips Head, determined by Börgesen, and the last from California, distributed in Collins, Holden, etc. Phyc. Bor. Amer., Exisc. n. 586. Börgesen's specimen exactly agrees with the illustration of the authentic specimen of *G. australe* J. Ag. shown in Gardner's l.c. pl. 44. On making a study of the structure of Börgesen's specimen of *G. australe* and Cotton's from Corea, the latter is quite different from that of the former. His specimens have the central cells of unequal size with rather plenty rhizoidal filaments in that tissue, while Börgensen's one has uniform-sized central cells with much intercellular spaces, and void of rhizoidal filaments. On this ground the writer's view stands at variance with Cotton's determination and his plants seem to be *Gelidium Amansii* f. *teretiusculum* n. f. mentioned below.

*G. Amansii* Lmx. is closely related to *G. tenue* sp. nov. and *G. subfastigiatum* sp. nov. When the plant in question has a very long frond, which is the case in those growing in deeper waters, it often appears like *G. linoides* Kütz., from which it may easily be distinguished by having many more closely arising alternate branches. From *G. tenue* sp. nov. the present plant differs in having many acute branches and not having thin and flat frond; from *G. subfastigiatum* sp. nov., by being less robust and by not having thickened apices and antrorse tooth-like ramuli near the apex of branches.

*Gelidium Amansii* Lmx.

*Fronds linear, ancipito-compressed, pinnately branched in alternate or opposite manner, often becoming filiform and subcylindrical in upper branches, sometimes very regularly and elegantly pinnated with equally long ramuli, but more usually more or less irregular in ramification. Branches sharp in apex, usually arising near together, but in others loosely and more remotely. Central cells 25–30μ in diam., mixed with smaller cells, more or less leaving intercellular spaces with a few rhizoids or almost none in the central tissue in the younger parts with many more in older, around which rhizoids are densely congested. Tetraspores collected in the terminal portion of ramuli forming elongato-ovate sori with a short pedicel. Cystocarps swollen beneath the apex of ramuli terminated with simple or branched apical segments.*

We may at least distinguish the following four forms:

f. *typica.* Pl. 19.

Frond of moderate size, 10–15 cm long, linear, ancipito-compressed, sometimes filiform and subterete above, with branches closely arising in

irregular manner, with sharp ramuli of unequal length. Very common and widely distributed in the Pacific and the Japan Sea.

f. *elegans* n. f. Pl. 20; pl. 31, fig. 3–5.

*G. elegans* KÜTZ. Tab. Phyc. XVIII, p. 18, tab. 52, f. c-d.

Frond of moderate size as f. *typica*, linear, ancipito-compressed, sometimes filiform, elegantly 2–3 times pinnate, with ramuli of almost equal size. Distribution same as f. *typica*.

f. *elatum* n. f. Pl. 21.

Frond very long, 30 cm. or more, linear or filiform, compressed, with branches and fertile ramuli distantly set. Found in deeper waters in the Prov. Ise, Sima, Idzu, Sagami and Bosyu.

f. *teretiusculum* n. f. Pl. 22; pl. 31, fig. 5–7.

*G. Australe* (non J. AG.) COTTON Mar. Alg. from Corea (Kew Bull. 1906.)

Frond of moderate size, slender, filiform, subterete, loosely and very irregularly branched with longer and shorter rather weak ramuli, with branches often slightly winding and with tetrasporic ramuli distantly set. Mostly found in Setonaikai (the Inland Sea of Japan), *e.g.*, in bays of Hirosima and Iyo.

*Gelidium tenue* sp. nov. Pl. 23; pl. 31, fig. 8–10.

Fronds thin and flat, broadly linear, 3–4 times disticho-pinnate, of moderate size, with branches elongated, opposite or alternate, elegantly pinnated with simple ramuli of subequal length. Rhizoidal filaments congested in the outer part of the medullary layer and almost none in the latter, where cells are relatively uniform in size having diameter of 20–30 $\mu$; filaments becoming more dense in the thicker portion. Tetrasporangial ramuli oblong or obovato-lanceolate, shortly pedicelled. Cystocarps formed beneath the apex of ramuli with simple or branched apex.

Hab.: Perhaps in deeper waters; ranging from Prov. Kii to Kazusa, Hatidyo-dima.

Fronds caespitose, thin and flat, broadly linear, not flexuous, 3–4 times pinnate, distichous, 15–20 cm high, 0.7–2 mm broad, sometimes slightly ancipitous on the lower portion of stem. Branches elongated, patent, alternate or opposite, elegantly pinnated with mostly simple ramuli of subaequal length. Thickness of the frond 200–380 $\mu$. Branches more or less tapering gradually toward the base and end in acute apex. Cortical cells polygonal,

irregularly arranged, 9–11 $\mu$ broad, a little elongated radially in cross-section. Rhizoidal filaments collected in the outer portion of the central tissue and almost none in that tissue, where the cells are relatively uniform in size having the diameter of 23–30 $\mu$; but in the thicker portion, rhizoids become densely congested both in the outer and central tissues leaving three-cells-thick infra-cortical layer free from them. Tetrasporangial ramuli oblong or ovato-lanceolate, with short pedicel. Cystocarps formed beneath the apex of ramuli with simple or branched apex. Colour light purplish red. Substance soft-cartilaginous, becoming more firm with age.

Characterised by thin and flat pinnate frond, having mostly simple ramuli elegantly pinnated along both sides of elongated branches. *Gelidium tenue* is allied to *G. Amansii* Kütz., from which it differs by thinness of frond and by not having spinescent branches. It is, however, often difficult to distinguish the former from the latter having regular and elegantly arranged ramuli.

*Gelidium subfastigiatum* sp. nov. Pl. 24; pl. 32, fig. 1–3.

Fronds robust, linear, thickish, ancipito-compressed, slightly flexuous upward, branching in pinnate manner in 3 or more orders, with alternate, opposite or often a few secund arrangement. Branches becoming thicker toward the apex, and ramuli on the terminal portion of branches often curving like antrorse teeth. Cells of the central tissue variable in size, attaining the diameter up to 20–23 $\mu$. Rhizoidal filaments congested on the outer side of the central tissue, where few of them are scattered. Tetrasporic sori ovato- or oblongo-lanceolate in broader elongato-ovate apex of ramuli, with a short pedicel. Cystocarps unknown.

Hab.: On rocks between tide marks near low tide; from western coast of Hokkaido down to Prov. Iwaki on the Pacific side through the Strait of Tsugaru.

Fronds few caespitose, thickish, ancipito-compressed, or often subterete, 10–25 cm high, up to 2 mm broad; basal broader portion measures 215–230 $\mu$ in thickness, becoming subterete upward attaining a diameter up to 400 $\mu$ in thicker part. Branches densely pinnate in three orders for the most part, distichous, alternate, opposite, or often a few arising in secund manner; all clothed more or less with short, widely spreading ramuli. Branches acute and usually slightly thickened toward apex tapering gradually toward the insertion, and ramuli on the terminal portion of branches often appear like antrorse teeth. Surface cells arranged without any definite order,

slightly elongated in radial direction in cross section; cells of the central tissue varying in size, attaining a diameter of 20–23 $\mu$. Rhizoidal filaments few in the central tissue becoming more numerous in the lower portions, and mostly congested on the outer side of that tissue. Tetrasporangia forming ovato- or oblong-lanceolate sorus in the broader elongato-ovate apex of ramuli, with a short pedicel. Cystocarps unknown. Colour dark purple becoming blackish on drying. Substance cartillaginous.

From allied species, especially, *G. Amansii* Lmx., which is much alike in the structure of the frond, the present plant is distinguished by being more robust and by having antrorse tooth-like ramuli toward the apex to branches which are slightly thickened upward. Colour is usually dark purple often changing to blackish in drying. There are often such forms as are not easily distinguishable from *G. Amansii* Lmx.

The plant in question seems to me to be a native of the regions of colder water mixed with warmer current, and thence distributed through the Straight of Tsugaru by the cold Kurile Current on the one hand to the western coast of Hokkaido, and toward Kinkwazan on the other.

*Gelidium vagum* sp nov. Pl. 25; pl. 32, fig. 8–70.

Fronds linear, thin and flat, 5–10 cm high, pinnate, with branches more or less not uniformly broad, usually broader in stem and filiform above, with short and distichous ramuli. Surface cells angular and elongated, 7–9 $\mu$, up to 14 $\mu$ long in surface view, rather longitudinally arranged and elongated radially as seen in the cross section; cells of the central tissue roundish, almost uniform in size with thickish wall, 23–30 $\mu$ in diameter gradually becoming smaller outward; rhizoidal filaments scattered in the central tissue, a little more congested in its external layer. Tetrasporic sori globular or ovate, very shortly pedicellate or almost sessile; cystocarps ovato-globular with short pedicels, pointed or muticous.

Hab.: On rocks between tide marks extending to beneath low tide; from western coast of Hokkaido to Prov. Iwaki through the Strait of Tsugaru along the Pacific coast and in the Japan Sea as far south as Prov. Wakasa, rarely found in Yokohama and Kamakura also in Osaka Bay.

Fronds mostly thin and flat, in older ones becoming thicker and compressed. The plant usually small in size, but some are a little longer, 5–10 cm high. Branches some times very regularly pinnate, while in others more irregular. They are patent, arising on roundish axils, not uniform in

breadth, usually broader in primary segments (2–3 mm) and gradually or suddenly tapering upward to filiform segments. Ramuli distichous, of almost equal length, mostly short, 2–4 mm long, the longer ones sometimes again branched. Thickness of frond 230–350 $\mu$. In some fronds branches are furnished with minute wart-like proliferations from the surface of main branches in the form of tuberiform processes, and in thin and soft fronds branches are often twisted. Infra-cortical cells often appear to be sub-isodiametric and parenchymatous.

The structure of frond varies according to localities, some reminding us of that of *Pterocladia tenuis* n. sp. by having rhizoids sometimes almost uniformly scattered in the central tissue. In some specimens, they are more dense in the central tissue while in others less so or almost none in that layer. Usually the northern forms are richer in rhizoides, but the southern forms poorer.

Tetrasporic ramuli globular or oblong-ovate, with very short and fine pedicels. Cystocarps ovato-globular with short pedicels, longly pointed or muticous. Fertile remuli are short and fine and elegantly arranged close together along both sides of branches.

*Gelidium linoides* Kütz. Pl. 26; pl. 32, fig. 11, 12.

Kütz. Tab. Phyc. XVIII, p. 20, t. 58, f. a-b. Yendo Notes on Algae new to Japan, I (1908), p. 128.

Fronds high, densely tufted, filiform, complanated below, irregularly and remotely branched in subdichotomo-alternate manner, often here and there arising near together. Ramuli short and sometimes almost none in sterile frond or very few distantly placed. Tetrasporangial ramuli short and fine, and distantly scattered.

Hab.: On rocks in deep waters as deep as 18 fathoms; Prov. Kii Sagami, Idzu, Bosyu.

Fronds very densely tufted, filiform, elongated, 25–30 cm high or more, remotely branched in alternato-subdichotomous manner in 5–6 orders at the distance of 2–3 cm. At basal portion, frond is more broadly linear attaining a breadth of 1–2 mm. Branches compressed, ca. 200 $\mu$ thick, with fine alternate or opposite short ramuli standing very remotely; they have afterward tetrasporangial sori in their narrowly oblong apical portion, tapering to a short pedicel. Cystocarps unknown. Cells of the central tissue roundish or transversely elliptical, of unequal size, 23–30 $\mu$ in diameter up to 37 $\mu$. Rhizoidal filaments congested on the external layer of the central

tissue, in which few are scattered. Substance soft cartilaginous.

At an early growth frond is not so regularly pinnate as in *Gelidium Amansii,* and from the later, especially from f. *elatum,* the present plant is easily distinguished by its alternato-dichotomous branching and tenderness of the substance.

The present plant shows some resemblance to *G. nudifrons* Gardn. and *G. arborescens* Gardn.,[1] especially to the former, by having sparse and scattered fruits and by the absence of short subultimate ramuli usually abundant in other species of this genus. But it differs from the former by not having fronds broadly oval in cross-section and from the latter by not having decidedly cartilaginous and rigid subcylindrical frond.

*Gelidium decumbensum* sp. nov. Pl. 27; pl. 32, fig. 7.

Fronds linear, complanato-flat, decumbent(?), without purcurrent stem, irregularly and distichously pinnate, patent, slightly tapering toward insertion and ending in blut apex; from or near the insertions of branches or from margins, slender branches of unequal length often arise subfasciculately or near together by which branches come in junction and loosely entangled; rhizoidal filaments few, scattered in the central tissue and densely congested in infra-cortical layer, with the cells of the central tissue not uniform in size. Tetraspores and cystocarps unknown.

Hab.: Cast up ashore at Enoshima.

Only two specimens in sterile state are known at present. Frond complanated, decumbent(?), without percurrent stem, irregularly and distichously pinnate, alternate or opposite, about 8 cm long, 1–2.5 mm broad. Branches patent, distantly set, often slightly curved, gently tapering toward insertion and ending in broadly blunt apex. Pinnately arising ramuli as is commonly seen in other species of the genus are not known, but furnished with short branches scatteringly. From or near insertions of branches, or from margin, sometimes from surfaces arise shorter or longer slender branches, either singly or in clusters; they come in conjunction with other branches or probably with the substratum and by this way the plant may become decumbent. Some of those slender branches develop to longer ones. In cross-section of frond rhizoids are scatteringly present in the central tissue, but densely congested in the infra-cortical layer. Cells of the central tissue unequal in size.

1) Gardner, N. L. New sp. of Gelidium on the Pacific Coast of N. Amer. p. 274 & 276, pls.

At a glance, the present plant seems to resemble *Pterocladia tenuis* sp. nov., but it differs from that species not only by having no regularly pinnate arrangement of branches, but also in the structure of frond; for, in frond of *Pterocladia* there is no rhizoid around the central tissue, as I have stated in the introductory remarks. It is of common occurrence in the several species of *Gelidium* and *Pterocladia* to shoot out abnormal slender root-like branches under certain conditions, but even in such cases root-like proliferations are very few and are not so numerous as in the present plant. Apart from that character, there is none among already known species to be identical with the present plant. Enosima is our most familiar place for gathering algae and frequently visited, yet the writer collected the present alga there, for the first time, this year. I can not decide whether or not the plant in question is an abnormal form of some known species. Yet, I describe provisionally this plant as a new species until full characters become known by getting more sufficient specimens.

*Gelidium clavatum* sp. nov. Pl. 28; pl. 32, fig. 4–6.

Frond linear, complanated, pinnately branched, alternate or opposite, very patent, not flexous; all branches provided with short and blunt very patent ramuli; branches obtuse at apex, about 20 $\mu$ thick; cells of the medullary layer almost uniform in size, 23–28 $\mu$ in diameter, with intercellular spaces, with few rhizoidal filaments which are mostly congested on the outer portion of the medullary tissue; tetraspores unknown; cystocarps formed beneath the apex of ramuli, one or rarely two seriated one after the other.

Hab.: Yendo's Herb. n. 87 from Bokoto; Amoi (Okamoto).

Only two specimens, one 5 cm, the other 12 cm high. The plant in question is easily distinguished by very patent branches and ramuli with blunt apex, together with the structure having intercellular spaces in the central tissue which consists of cells almost uniform in size. Papillary ramuli are proliferated from surfaces in one of the specimens.

## **Pterocladia** J. Ag.

As stated in the introductory remarks, the rhizoidal filaments are seen in the central tissue only, either densely or scatteringly. Cells are more or less angular like parenchymatic cells of wide calibre, especially in the infra-

cortical ones, and have thinner walls. Carpostome is more or less elevated like a beak with a larger and roundish opening.

*Pterocladia tenuis* sp. nov. Pl. 29; pl. 30, fig. 3; pl. 33, fig. 1–3.

*Pt. capillacea* (non BORN. et THUR.) OKAM. Icones, III, p. 50, pl. CXV.

Fronds thin, compressed, and almost flat, linear, regularly 3–4 times pinnate in pyramidal outline, closely or distantly branched; branches of every order gradually or abruptly narrowed toward insertion ending mostly in blunt apices; rhizoids scattered only in the middle portion of the central tissue in younger part, becoming gradually denser in older parts; tetraspores forming roundish or oblong sori; cystocarps formed beneath the apex of ramuli, crowned with apical prolongation.

Hab.: On rocks extending from between tide marks to deeper waters; widely distributed on both coasts of the Pacific and the Japan Sea, extending from Kyûsyû to the western coast of Hokkaido. Pei-tai-ho (COWDRY's specimen n. 541).

Fronds compressed, thin and almost flat, rather broadly linear, regularly 3–4 times pinnate in pyramidal outline, opposite or alternate, very patent, 10–20 cm high; branches gently or abruptly tapering toward base and constricted at insertion, 1–2 mm broad, gradually narrower in the lesser ones, mostly broader and obtuse at apex, sometimes tapering upward. The arrangement of branches varies according to the depth of the habitat; in fronds growing in deeper waters (some 10 fathoms) branches are distantly set and loosely arranged, while those in shallower parts they become approached and more closely branched. Those two forms are often seen in one and the same frond, branches of the upper part being densely pinnated while those of the lower loosely disposed. Fronds attain 110–280 $\mu$ in thickness, 150–200 $\mu$ being more usual.

Rhizoidal filaments are few, scattered in the middle portion of the central tissue being more densely congested in both margins of branches, and becoming more and more numerous in the central tissue in the lower or older parts of frond, without being congested beneath infra-cortical layer as in most species of *Gelidium*. Frond seems as if composed of isodiametrical cells, especially in the younger part where rhizoids are scarce in number.

Tetrasporic sori, at the beginning, forming roundish patches in ultimate ramuli, becoming gradually elongated and oblong, and often sori become confluent with those of lateral ramelli in broader ones. Margin of soriferous

ramuli often is not even. Cystocarps formed on the median line of ramuli, swollen out on one side with a little prominent and wide carpostome.

The present plant is very closely related to *Pterocladia densa* sp. nov. so much so that both plants are not often easily distinguished one from the other. In *Pt. densa* rhizoids are densely congested in the central portion of the medullary tissue even in ultimate ramuli, while in the present plant they are very few, being here and there scattered in the cross-section of younger part, though they become more dense in older and thicker portion of frond. The broader branches of *P. densa* is narrowed toward insertion, but lesser ones not; in the present plant almost all branches taper toward the base.

The plant in question closely resembles *Pterocladia capillacea* (Gmel.) Born. et Thur. somewhat in external appearance and in the structure by having few rhizoids in the central tissue of the younger part. Some of our plants have almost similar habit as *P. capillacea* Born. et Thur. which is also variable in external appearance according to localities, as I have studied by various specimens from several parts of the world, such as Sydney (Mus. Godeffroy Hamburgensis, det. by A. Grunow), Wembary (det. by Cotton), Azores and Corsica (det. by Börgesen) and Dalmatia (Fl. Exsic. Austro-Hungary, n. 2383). Among us the present plant passed under that name, but Howe expressed his opinion that he can not agree with my determination of *P. capillaris* Born. et Thur. in Cowdry's Peitaiho Algae. On closely studying our plant by comparing with reliable specimens mentioned above, our plants are, as a chief distinction, pyramidal in outline, having more broad branches, while *P. capillacea* is less broader, often more irregularly branched than ours and not constricted always to have pyramidal outline.

*Pterocladia densa* sp. nov. Pl. 30; fig. 1–2; pl. 33, fig. 4–8.

Fronds filiform or linear, very densely branched pinnately in a pyramidal outline, 3–4 times alternate or opposite, with a percurrent stem, 10–15 cm high; branches and lesser sorts arising near to each other, widely parted; stem and main branches compressed and thickish; ramuli subtereto-compressed, broader branches tapering toward the base, narrower ones and ramuli not constricted at insertion and end in a narrow apex, not being broadly expanding. Tetrasporic ramuli slightly broadened toward apex, forming elliptico-oblong or ovate sori. Cystocarps swollen beneath the apex of ramuli terminated with apical prolongation.

Hab.: On rocks between tide marks; Kashiwadima, Prov. Tosa; Hatydyo-dima; Prov. Inaba.

The plant in question has sometimes an appearance strongly resembling a form of *Gelidium Amansii* LMX., from which the structure of frond differs in having rhizoids in central tissue, instead of its outside. From *Pt. tenuis* the present plant differs in more slender and densely set branches as well as by having densely congested rhizoids even in younger part of branches.

*Pterocladia nana* OKAM. Pl. 33, fig. 9–12.

OKAM. Icon. Japan. Algae, VI, p. 57, pl. CCLXXVIII, f. 1–14.

Fronds dwarf, arising from creeping filamentous roots, linear, ancipito-compressed, 3–4 times closely and distichously branched in opposite or alternate manner in a corymbose outline, attaining the height of 2–2.5 cm; branches of every order gently tapering toward their bases, patent, 0.3–1.5 mm broad, sometimes some of them becoming filiform like stolon toward their apices forming root-like discs; rhizoidal cells evenly scattered in the inner tissue not being dense in infra-cortical layer. Tetrasporangia forming a roundish oval or elongato-oblong sorus in a little expanded apical portion of ultimate ramuli, often two or more sori of lateral branchlets becoming confluent; cystocarps ovate, with a little prominent wide ostiole formed on the median line of either surface of ramuli beneath more or less elongated ligulate or lanceolate apical segments.

Hab.: On rocks or branches near high tide facing dashing waves; Seto (Prov. Kii), Prov. Tosa, Koshikidima (Prov. Satsuma), Prov. Ettyu.

---

**Explanations of Plates 16-33**

Pl. 16. Fig. 1. Fronds of *Gelidium divaricatum* MARTENS in nat. state and size, 1/1.
Fig. 2. Two pieces of fronds of the same detached, 1/1.
Fig. 3. Fronds of *Gelidium crinale* (TURN.) LMX., 1/1.
Fig. 4–5. Two young fronds of *Gelidium pacificum* OKAM., 1/1.
Fig. 6. Tetrasporic frond of the same, 1/1.
Pl. 17. Fig. 1. Fronds of *Gelidium pusillum* (STACKH.) LE JOL., 1/1.
Fig. 2. Two pieces of the same detached, 1/1.

Fig. 3. Fronds of *G. pusillum* f. *foliaceum* nov. f. from Shiso-dima, Seto, Prov. Kii, 1/1.
Fig. 4. Fronds of fig. 3, magd., 100/1.
Fig. 5. Fronds of *G. pusillum* var. *conchicola* Picc. et Grun. from Wagu, 1/1.
Fig. 6. Same as fig. 5 sketched to show the habit of fronds, 1/1.

Pl. 18. Fig. 1. Fronds of *Gelidium subcostatum* Okam. bearing cystocarps, 1/1.
Fig. 2. Frond of *G. japonicum* (Harv.) Okam., 1/1.

Pl. 19. Fig. 1. Young frond of *Gelidium Amansii* Lmx. f. *typica*, n. f., 1/1.
Fig. 2. Sterile frond of the same, 1/1.

Pl. 20. Two tetrasporic fronds of *G. Amansii* Lmx. f. *elegans* n. f. from Enoshima, 1/1.

Pl. 21. Tetrasporic fronds of *Gelidium Amansii* Lmx. f. *elatum* n. f. from Susaki, Prov. Idzu, 1/1.

Pl. 22. Two tetrasporic fronds of *Gelidium Amansii* Lmx. f. *teretiusculum* n. f., from Prov. Iyo, 1/1.

Pl. 23. Two fertile fronds of *Gelidium tenue* sp. nov., from Enoshima, 1/1; upper one, tetrasporic; the lower, cystocarpic.

Pl. 24. Two fronds of *Gelidium subfastigiatum* sp. nov., 1/1.
Upper one, sterile frond from Oshoro, Hokkaido; the lower, immature-tetrasporic frond from Kotomo, Pref. Miyagi.

Pl. 25. Fronds of *Gelidium vagum* sp. nov. from different localities, 1/1.
Fig. 1. Cystocarpic frond from Onahama, Prov. Iwaki.
Fig. 2. Sterile frond from Shiranuka, Pref. Awomori.
Fig. 3. Sterile frond from Shiwoya, Hokkaido.
Fig. 4. Tetrasporic frond from Gulf of Obama, Prov. Wakasa.

Pl. 26. Two fronds of *Gelidium linoides* Kütz., 1/1.
Fig. 1. Tetrasporic frond from Susaki, Prov. Idzu.
Fig. 2. Young frond from the same locality.

Pl. 27. Frond of *Gelidium decumbensum* sp. nov. from Enoshima, 1/1.

Pl. 28. Two fronds of *Gelidium clavatum* sp. nov., 1/1.
Fig. 1. Tetrasporic frond from Bokoto, Taiwan.
Fig. 2. Sterile frond from Amoi, China.

Pl. 29. Three sterile fronds of *Pterocladia tenuis* sp. nov., 1/1.
Upper one from Inatori, Prov. Idzu; the lower two from Enoshima.

Pl. 30. Fig. 1. Typical frond of *Pterocladia densa* sp. nov., bearing tetra-

spores, from Kashiwadima, Prov. Tosa, 1/1.

Fig. 2. Very densely branched frond of the same, bearing tetraspores from Uratomi, Prov. Inaba.

Fig. 3. Tetrasporic frond of *Pterocladia tenuis* sp. nov., from Pref. Kôchi.

Pl. 31. Fig. 1. Portion of cross-section of frond of *Gelidium pusillum* (Stackh.) Le Jol. having rhizoids in the central tissue, 500/1.

Fig. 2. Portion of another frond of *G. pusillum* having rhizoids more dense in the infra-cortical layer, 500/1.

Fig. 3. Cross-section of a ramulus of *Gelidium Amansii* f. *elegans* n. f., (from Misaki), 12/1.

Fig. 4. Cross section of a branch of the same frond, 12/1.

Fig. 5. Middle portion of the fig. 3 magd, 500/1.

Fig. 6. Cross-section of the frond of *G. Amansii* f. *teretiusculum* n. f. from Prov. Iyo, 48/1.

Fig. 7. Portion of the fig. 6, 500/1.

Fig. 8. Portion of cross-section of frond of *G. tenue* nov. sp., 245/1.

Fig. 9. Tetrasporiferous ramulus of *G. tenue* nov. sp., 8.5/1.

Fig. 10. Two cystocarps from one and the same frond of *G. tenue* nov. sp., 8.5/1.

Pl. 32. Fig. 1. Portion of cross-section of the frond of *G. subfastigiatum* nov. sp. from Oshoro, 245/1.

Fig. 2. Tetrasporic ramuli of the same from Samé (Prov. Awomori), 7/1.

Fig. 3. Two tetrasporic ramuli of the same from Oshoro, 9/1.

Fig. 4. Portion of cross-section of the frond of *G. clavatum* nov. sp., from Amoi, 500/1.

Fig. 5–6. Two cystocarps of the same frond as fig. 3, 9/1.

Fig. 7. Portion of cross-section of the frond of *G. decumbensum* nov. sp. from Enoshima, 245/1.

Fig. 8. Portion of cross-section of the frond of *G. vagum* nov. sp. from Prov. Iwaki, 245/1.

Fig. 9. Tetrasporic ramulus of the same from Prov. Iwaki, 7/1.

Fig. 10. Cystocarp of the same, from the same locality 7/1.

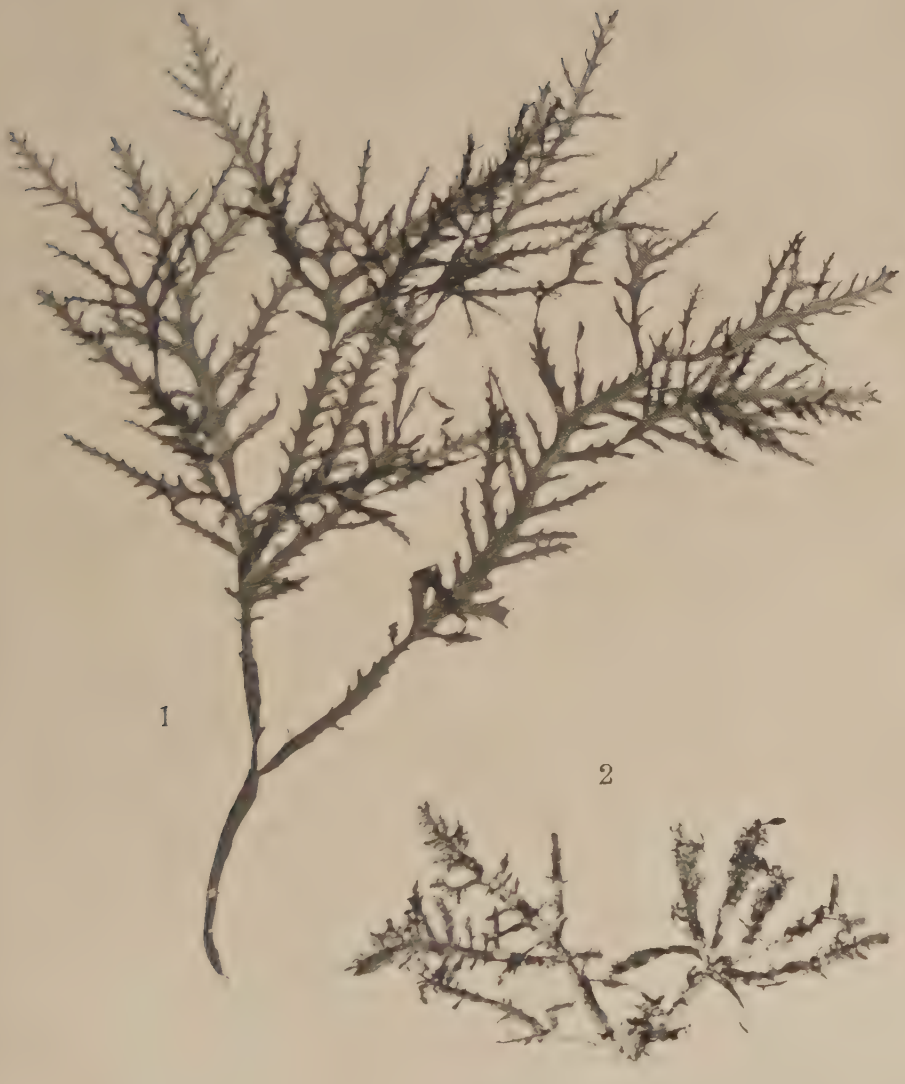
Fig. 11. Portion of cross-section of the frond of *G. linoides* Kütz. from Prov. Idu, 245/1.

Fig. 12. Tetrasporic ramulus of the same from Idu, 12/1.

Pl. 33. Fig. 1. Portion of cross-section of the frond of *Pterocladia tenuis* sp. nov. (from Prov. Idu), 245/1.
Fig. 2. Tetrasporic sori of *Pt. tenuis* (from the same loc.), 14/1.
Fig. 3. Cystocarp of *P. tenuis* (from the same loc.), 28/1.
Fig. 4. Portion of cross-section of the frond of *P. densa* sp. nov. from Kashiwa-dima (Prov. Tosa), 245/1.
Fig. 5. Tetrasporic branch of the same, 9/1.
Fig. 6. Cystocarpic ramuli of the same, 11/1.
Fig. 7. Left one of the ramuli in fig. 6, magd., 28/1.
Fig. 8. Vertical section of cystocarp of *Pt. densa* from Okitsu (Prov. Suruga), 28/1.
Fig. 9. Two cystocarpic fronds of *Pt. nana* OKAM. from Koshiki-dima, 1/1.
Fig. 10. Portion of cross-section of the frond of *Pt. nana* from Seto (Prov. Kii), 500/1.
Fig. 11. Tetrasporic ramuli of the same, 14/1.
Fig. 12. Cystocarp of the same, 14/1.

*Gelidium divaricatum* Mart., ひめてんぐさ, Fig. 1–2.
*G. crinale* (Turn.) Lmx., いとてんぐさ, Fig. 3.
*G. pacificum* Okam., おほぶさ, Fig. 4–6.

*Gelidium pusillum* (Stackh.) Le Jol., はひてんぐさ, Fig. 1-2.
*G. pusillum* var. *foliaceum* n. var., Fig. 3-4.
*G. pusillum* var. *conchicola* P. et G., Fig. 5-9.




*Gelidium subcostatum* Okam., ひらくさ, Fig. 1.
*G. japonicum* (Harv.) Okam., おにくさ, Fig. 2.

*Gelidium Amansii* Lmx., f. *typica* n. f., まくさ.

*Gelidium Amansii* Lmx., f. *elegans*, まくさ一形

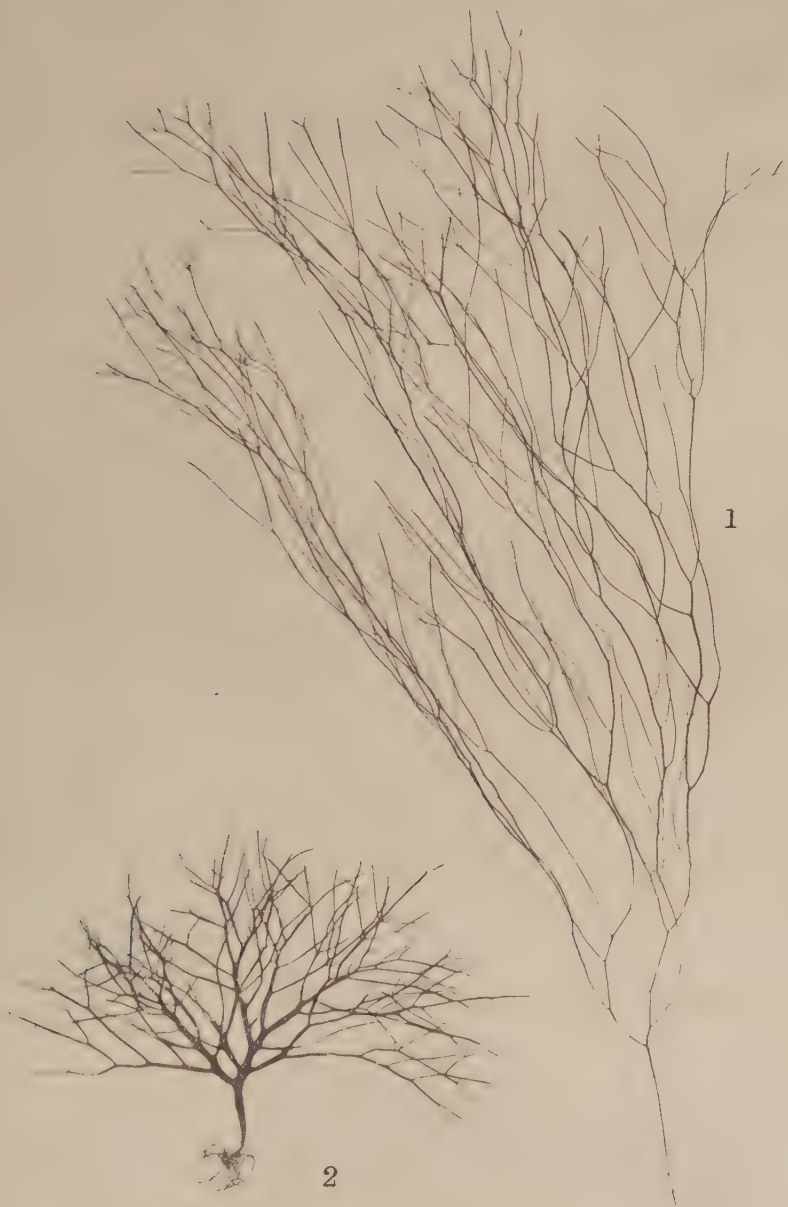
*Gelidium Amansii* Lmx., f. *elatum* n. f., まくさ一形.

*Gelidium Amansii* Lmx., f. *teretiusculum* n. f., まくさ一形.

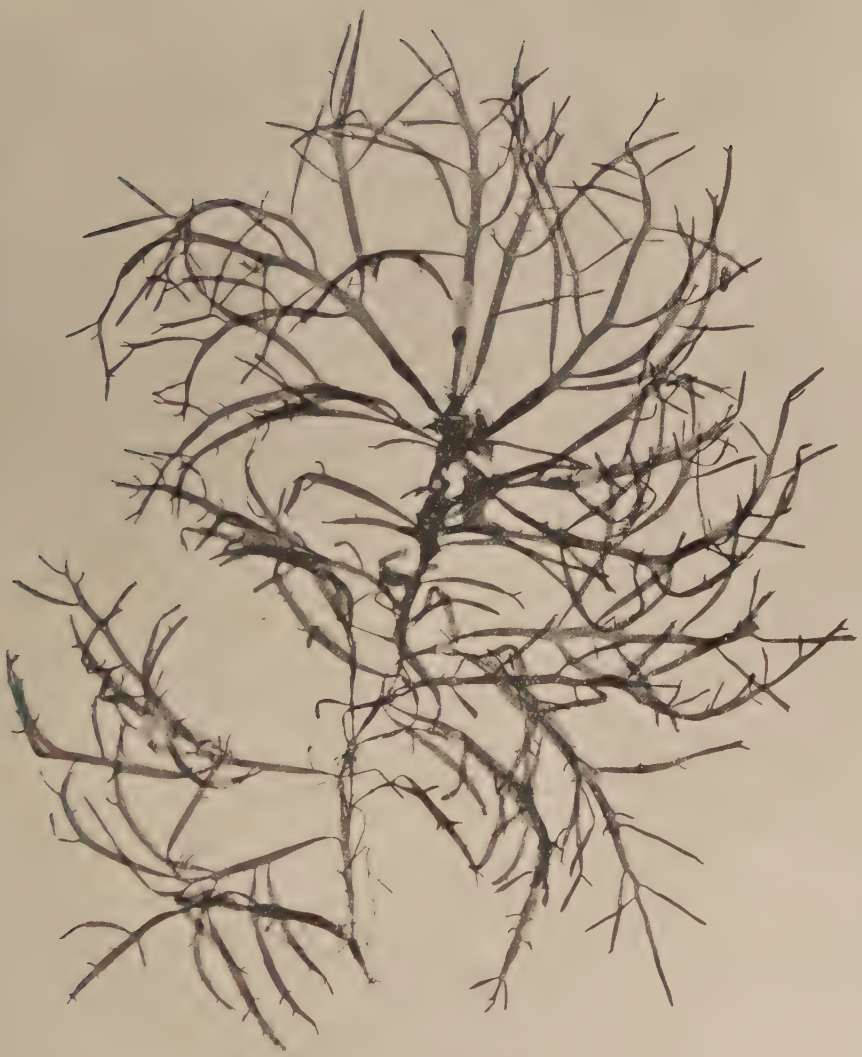
*Gelidium tenue* sp. nov., こひら.

*Gelidium subfastigiatum* sp. nov., なんぶくさ.

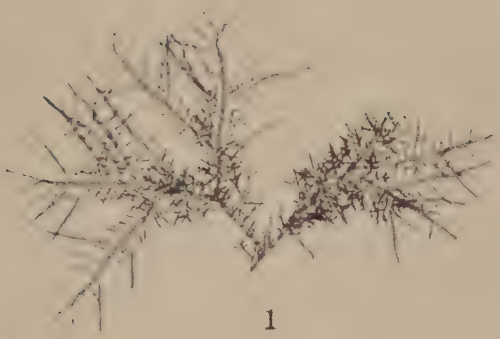
*Gelidium vagum* sp. nov., よれくさ.




*Gelidium linoides* Kütz., きぬくさ.



*Gelidium decumbensum* sp. nov., たをれぐさ.



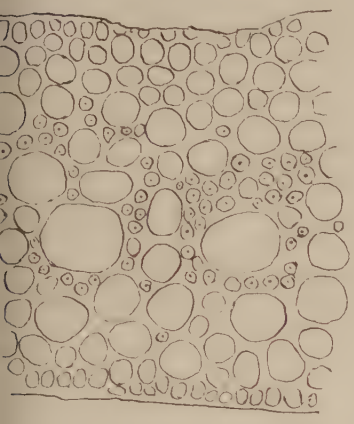
1

2

*Gelidium clavatum* sp. nov., しやくがたぶと.

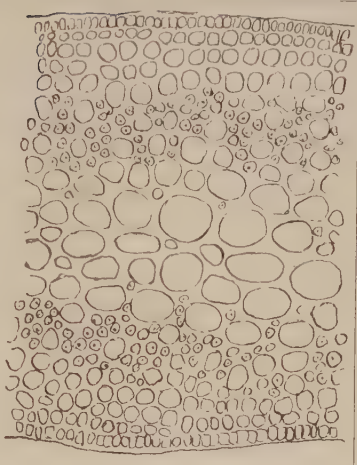
*Pterocladia tenuis* sp. nov., おばくさ.

*Pterocladia densa* sp. nov., かたおばくさ, Fig. 1-2.
*P. tenuis* sp. nov., おばくさ, Fig. 3.



1

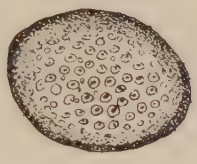
2



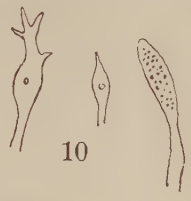
8

3

4

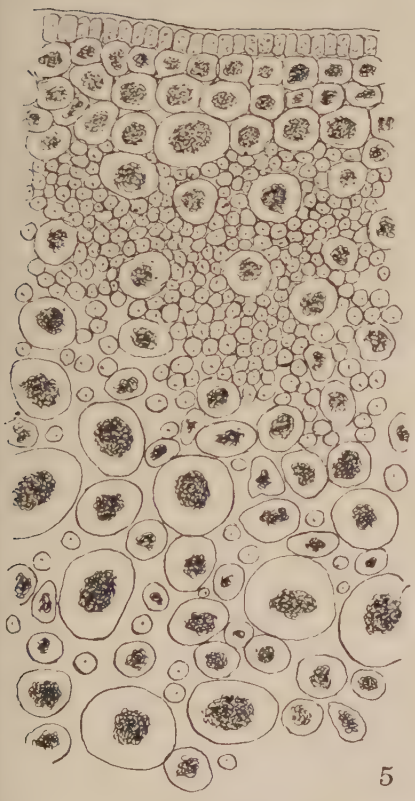


6

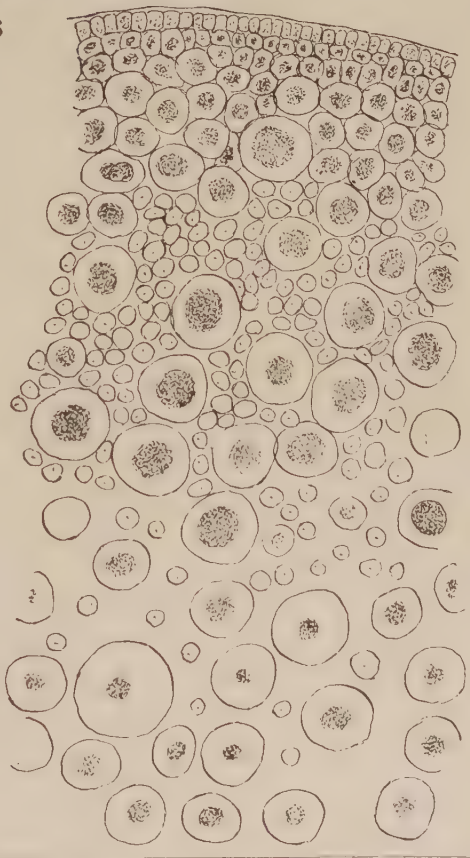


10

9

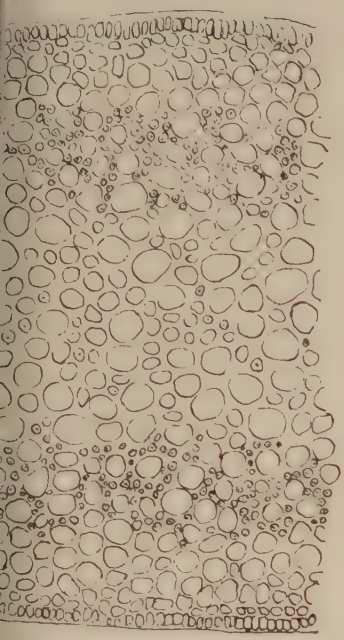


5



7

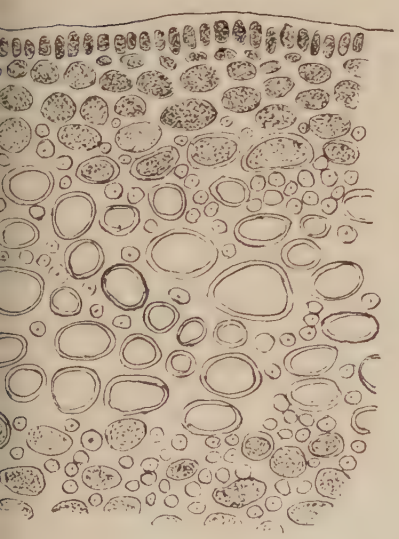
*Gelidium pusillum* (Stackh.) Le Jol., はひてんぐさ, Fig. 1-2.
*G. Amansii* f. *elegans* sp. nov., まくさ一形, Fig. 3-5.
*G. Amansii* f. *teretiusculum* sp. nov., Fig. 6-7.
*G. tenue* sp. nov., Fig. 8-10.



1

2

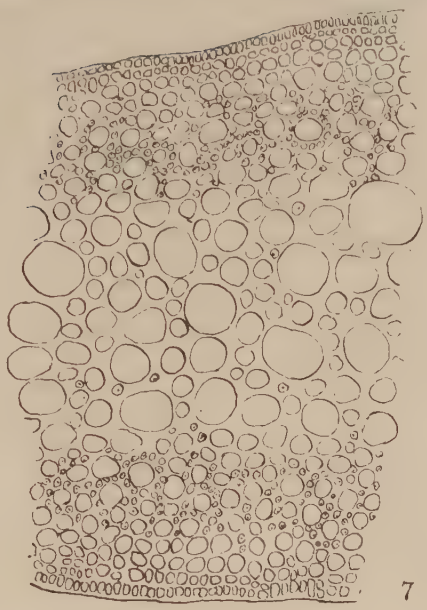
3



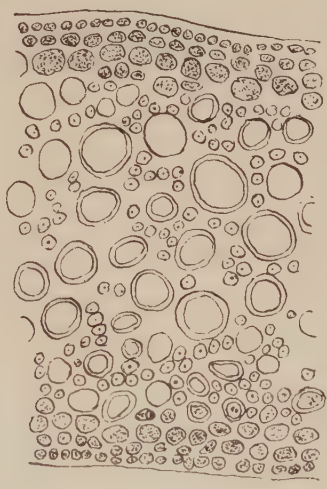
4

5

6



7



8

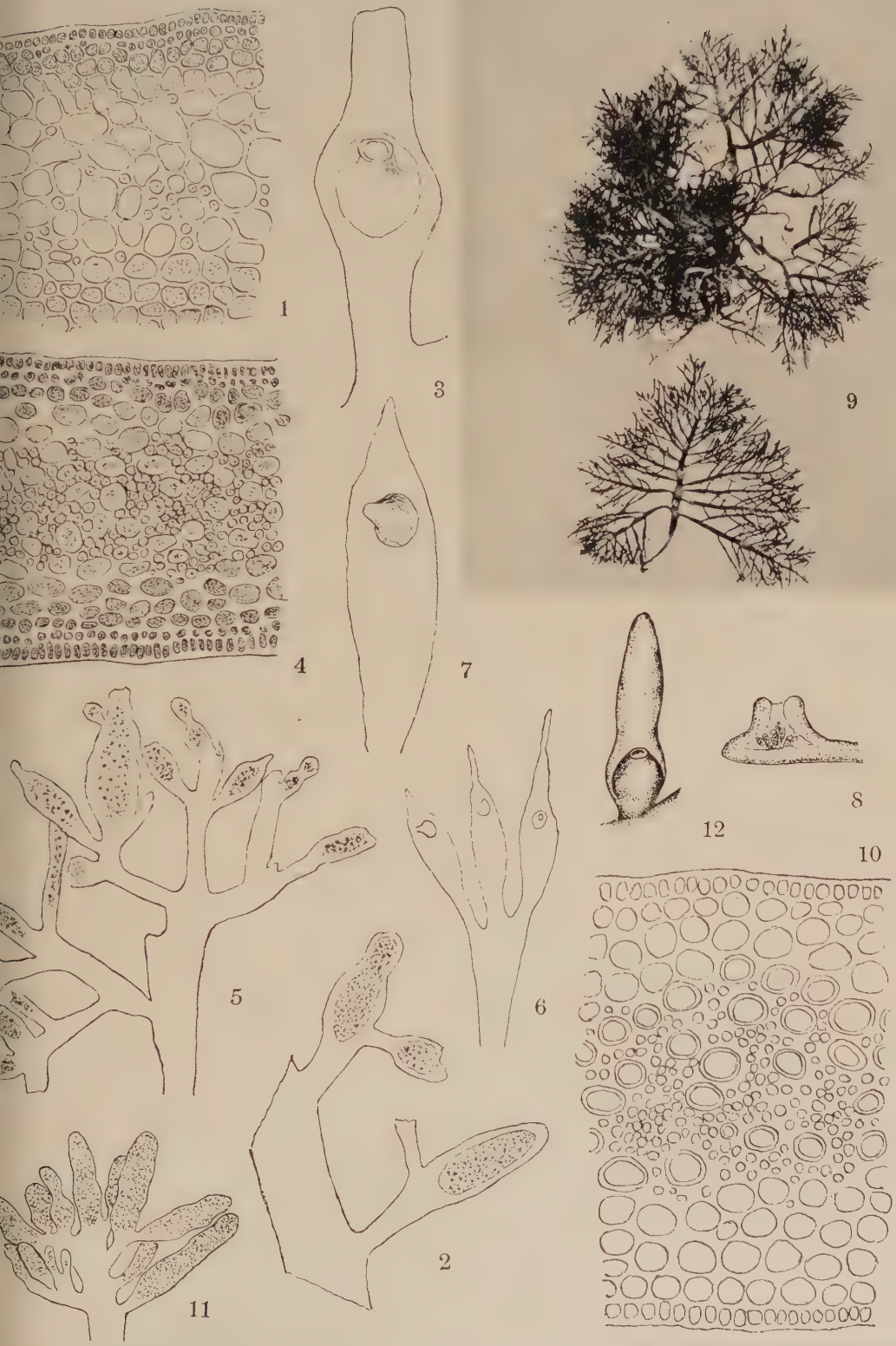
9

10

11

12

*Gelidium subfastigiatum* sp. nov., なんぶくさ, Fig. 1-3.
*G. claratum* sp. nov., しやくがたぶと, Fig. 4-6.
*G. decumbensum* sp. nov., たをれぐさ, Fig. 7.
*G. vagum* sp. nov., よれくさ, Fig. 8-10.
*G. linoides* Kütz., きぬくさ, Fig. 11-12.




*Pterocladia tenuis* sp. nov., おばくさ, Fig. 1-3; *Pt. densa* sp. nov., かたおばくさ, Fig. 4-8; *Pt. nana* Okam., ちやぼおばくさ, Fig. 9-12.

# On the Soundings from the Banks of Senoumi in the Suruga Bay, Japan.

(Sôyô-maru expedition.)

(Pl. 34–36)

By Hirosi Niino.

(Received Jan. 20, 1934)

CONTENTS

1. Introduction.
2. Physiography of the Suruga Bay and its environs.
3. Topography of the Banks of Senoumi.
4. Soundings from the Banks of Senoumi and their surrounding area.
5. Relation in geology, topography and fauna between the Banks and the land bordering the Suruga Bay.
6. Conclusion.
7. Literature.

## I. Introduction.

It has long been known that there exists a series of banks arranged in the NNE direction in the Suruga Bay on the Pacific side of central Japan. The northernmost bank is called Senoumi, the second one Nakanose, and the third Kanesunose (Fig. 1). In this paper these banks are called "the Banks of Senoumi."

In 1928, the surveying ship Sôyô-maru of the Imperial Fisheries Experimental Station dredged 19 bottom samples from Senoumi and Nakanose, along the coast of the Suruga Bay. Those samples were put at my disposal for examination through the kindness of the Director of the Imperial Fisheries Experimental Station; there are also used in this study some other materials collected by myself from the littoral zone of the west coast of the Suruga

Table I. Sounding stations on and around the Banks of Senoumi.

| Station Number | N. Latitude | E.Longitude | Depth in meters | Bottom temp. in °C | Bottom sp. gr. $S_4^{15}$ | Bottom character | Locality |
|---|---|---|---|---|---|---|---|
| | ° ′ ″ | ° ′ ″ | | | | | |
| 273 | 34 45 40 | 138 30 05 | 123 | 13.2 | 25.54 | S. M. | Senoumi |
| 274 | 34 44 40 | 138 30 40 | 51 | 17.5 | 25.61 | S. G. | „ |
| 275 | 34 40 20 | 138 32 00 | 62 | 16.3 | 25.86 | Cl. G. Pum. Sh. | „ |
| 276 | 34 43 50 | 138 30 50 | 77 | 15.0 | 25.64 | S. M. | „ |
| 277 | 34 43 30 | 138 29 30 | 91 | 14.8 | 25.64 | G. M. | „ |
| 278 | 34 42 50 | 138 30 30 | 79 | 14.8 | 25.50 | Cy. G. M. | „ |
| 279 | 34 42 10 | 138 30 40 | 155. | 12.3 | 25.58 | G. S. Sh. | „ |
| 280 | 34 42 50 | 138 28 15 | 273 | 9.3 | 25.50 | M. | „ |
| 282 | 34 39 30 | 138 28 40 | 110 | 14.8 | 25.64 | G. Sh. | Nakanose |
| 283 | 34 38 25 | 138 29 40 | 177 | 12.0 | 25.52 | G. M. S. Sh. | „ |
| 284 | 34 38 30 | 138 27 30 | 71 | 10.0 | 25.64 | G. P. | „ |
| 285 | 34 37 25 | 138 26 50 | 71 | 12.4 | 25.60 | G. P. | „ |
| 286 | 34 36 10 | 138 26 30 | 123 | 14.3 | 25.70 | S. M. | „ |
| 287 | 34 37 00 | 138 25 25 | 73 | 14.4 | 25.50 | G. M. | „ |
| 288 | 34 38 30 | 138 28 00 | 77 | 14.3 | 25.14 | G. M. Sh. | „ |
| 289 | 34 37 25 | 138 27 05 | 84 | 14.6 | 25.14 | G. S. M. | „ |
| 290 | 34 36 15 | 138 26 15 | 143 | 11.8 | 25.62 | Sh. S. M. | „ |
| 291 | 34 39 20 | 138 28 50 | 77 | 13.4 | 25.62 | S. M. | „ |
| 107 | 34 20 15 | 138 20 00 | 128 | 13.6 | 25.74 | M. | Off Sagara |
| 188 | 34 30 00 | 130 24 00 | 214 | 10.9 | 25.56 | | Off Cape Onmae |
| 264 | 34 45 00 | 138 21 30 | 280 | 11.5 | 25.55 | M. | Off Kawajiri |
| 265 | 34 36 30 | 138 23 00 | 450 | 8.0 | 25.47 | M. | Between Nakanose and C. Onmae |
| 266 | 34 38 30 | 138 29 00 | 128 | 14.3 | 25.75 | G. R. | East slope of Nakanose |
| 280 | 34 18 14 | 138 17 30 | 55 | 22.5 | 25.77 | G. | Kanesunose |
| 376 | 34 33 35 | 138 07 45 | 64 | 21.5 | 25.53 | R. | Southern shore of C. Onmae |
| 377 | 34 28 45 | 138 15 00 | 82 | 18.6 | 25.54 | R. | Off S. W. of Cape Onmae |

R....rock, G....gravel, P....pebble, Pu....pumice, Sh....shell
S....sand, Cl....clay, M....mud

N
Fig. 1, a
C
A
Sizuoka
Mt Kunô
Tôkaido
R. Ôi
Kawajiri
Makinohara
Sagara
Ikesinden
Jitokata
C. Onmae
Senoumi
Nakanose
Suruga
Gulf of
Matsuzaki
Izu Peninsula
I
II
III
IV
V
900
800
700
600
500
400
300
200
100
50
60
2000
1000

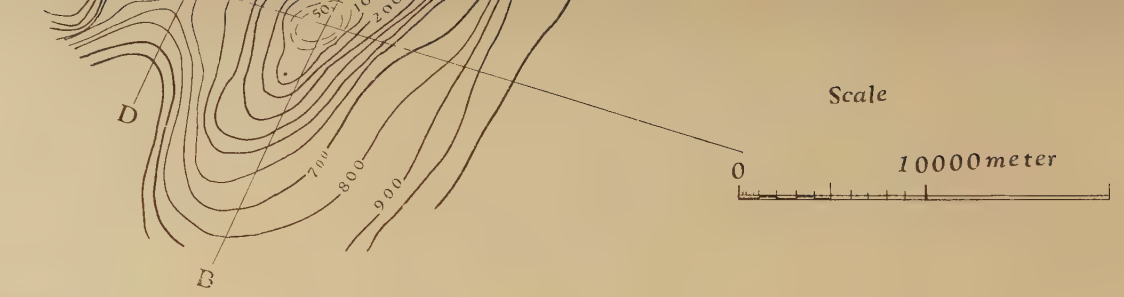



Fig. 1, b

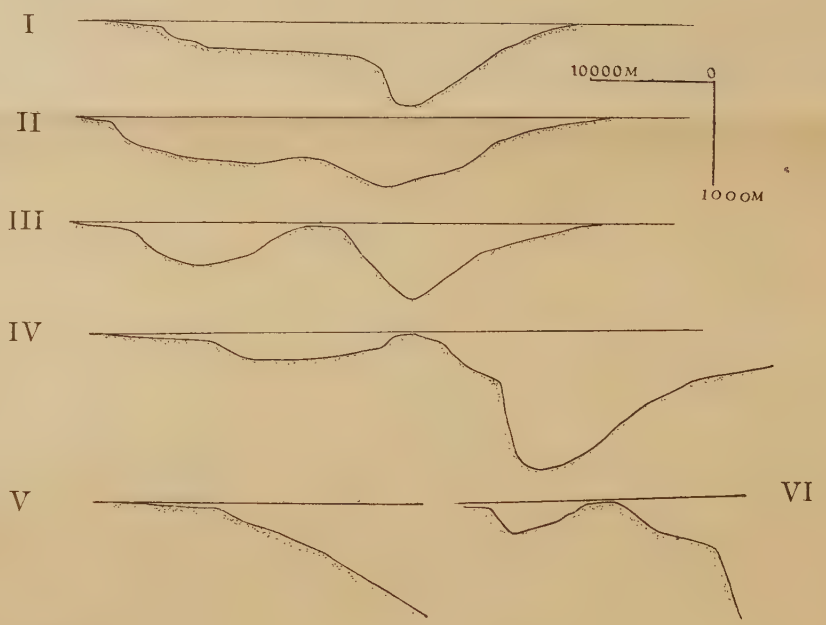



Fig. 2.

Fig. 1, c

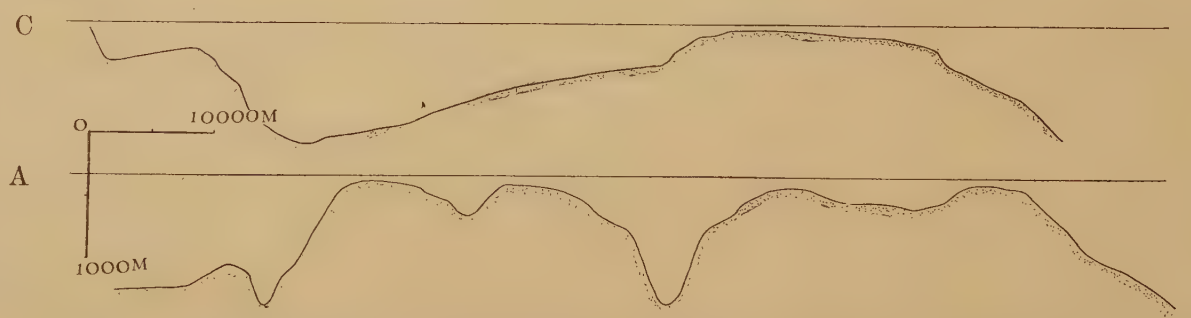



Fig. 1, a Bathymetric feature the Banks of Senoumi. The black spot shows surveying station. Conter interval 100 meters. [from chart *No.* 80, Imperial Navy]

Fig. 1, b, c Its section.

Fig. 2. Geotectonic map of Japanese Island showing relation between the Banks of Senoumi and *fossamagna*.

Bay between Cape Onmae and Kawajiri, and those collected around Idu Peninsula.

## II. Physiography of the Suruga Bay and its environs.

The Suruga Bay lies between Idu Peninsula on the east and the upheaved coastal platform of Makinohara on the west. It is 60 km. long, from its mouth to the head, 57 km. wide at the mouth from Cape Iro in Idu Peninsula to Cape Onmae, and about 36 km. wide at the head from the Port of Simidu to Siduura. The bay shows a characteristic bathymetric feature which consists in a deep through sounded near the east border of the bay, i.e. along the west coast of Idu Peninsula; it is more than 3000 m., 2000 m. and more than 900 m. deep at the mouth, the middle portion, and the head off Port Simidu respectively. The east border of the trough is a sea floor incline at about 9.5° from shore to 2000. bathymetric line, whereas the west side is that rising at about 18° to the Banks of Senoumi. The summits of these banks attain a depth of 60 m. below the sea level and are arranged on a line 60 km. long north to south, in the midst of the Suruga Bay. Extended between the west border of the Banks and the west coast of the Suruga Bay is a shallow sea of about 300 m. in depth. Between the Banks of Senoumi and the north coast of the Suruga Bay, i.e. to the south of Mt. Kunô, there lies a conspicuous round depression more than 900 m. in depth, which is connected eastwards by a linear depression to the deep trough on the east. A delta is developed at the mouth of the River Ooi and another at that of the River Fuji.

The meridional deep trough in the Suruga Bay is ichthyologically very noteworthy, on account of its being frequented by deep sea fishes. It is also very instructive geologically, as it may represent a tectonic scar subparallel to the southern part of the Shiduoka-Itoigawa tectonic line, or the western rim of the so-called *fossa magna*, tectonic divide of north-east and south-west Japan.

## III. Topography of the Banks of Senoumi.

Senoumi is a bank situated at the northern end of the Banks of Senoumi; it lies the midway between Matsuzaki in Idu Peninsula and the mouth of the River Ooi, and is 18 km. off the west coast of the Suruga Bay. The shallowest part is at the northern corner of the bank and 32 m. in depth. It is outlined by the 200 m. bathymetric line, oval in shape, 9.6 km. long

and 6.5 km. broad.

Nakanose lies 2 km. SW of Senoumi, its shallowest part being 71 m. in depth. The largest diameter of the area border by 200 m. bathymetric line is 11 km. and the shortest 4.2 km.

Kanesunose, the southernmost one is 28 km. SSW of Nakanose and 27 km. off Cape Onmae. The shallowest part of this bank is 51 m. in depth and its 200 m. bathymetric line forms the shape of a shield, 8 km. long and 14 km. across. The Banks are separated from the submarine platform along the west coast of the Suruga Bay by a channel of more than 300 m. in depth.

## IV. Soundings from the Banks of Senoumi and their surrounding area.

Bottom materials dredged from the Banks of Senoumi and their surrounding sea floor from the sounding stations are through a 2 mm. mesh.

### *Gravels, in general.*

Gravels were collected from 21 stations on the Banks and several stations on submarine platform. The largest one measures 19 cm. in diameter and 690 gr. in weight; but those of about 5 cm. in diameter are the commonest ones. It is noteworthy that the size of gravels on the Banks gradually decrease towards the south, and that the same tendency is exhibited by gravels of the Pleistocene gravel bed developed in the west coast. On submarine slope of the same coast, gravels were dredged from several stations but none dredged from the stations in the linear deep between the Banks and the submarine platform. Table II shows the measurements of size, weight, shape and other aspects of the largest gravel dredged from each station on the Banks of Senoumi.

### *Surface feature of the gravels.*

Hard pebbles are well water-worn and bear no striæ nor pits on the surface. Gravels from above 100 m. in depth are notably encrusted by organisms, while those from deeper waters are relatively less so. The encrusting organisms are calcareous algae, bryozoa, etc. On some gravels dredged from a station 70 m. in depth, living oyster shells were found. Gravels of soft rocks such as shale or tuffaceous sandstone bear frequently bore-holes of boring shells, sometimes with the tests still intact in the holes.

## Table II. Measurement of the largest pebble from each station dredged on the Banks of Senoumi.

| Station Number | Depth in meter | Weight in gram | Length in cm. | Breadth in mm. | Thickness in cm. | Kinds of the measured pebble | Shape | Surface | Adhesion of organism | Kinds of the other gravels, megascopic determination. |
|---|---|---|---|---|---|---|---|---|---|---|
| 291 | 77 | 21 | 3.1 | 3.0 | 2.7 | Gr. | R. | Sm. | Al. Br. | Ch. S.S. |
| 290 | 143 | 41 | 5.3 | 3.94 | 1.82 | Gr. | R. | Sm. | — | Ch. Gr. Pum. |
| 288 | 177 | 346 | 7.2 | 4.8 | 1.6 | Gr. | R. | Sm. | Al. Br. | Gr. S.S. S.S. (Soft) |
| 287 | 73 | 18 | 4.8 | 4.3 | 2.2 | Gr. | R. | Sm. | Al. | Gr. Q. Tuff. |
| 286 | 123 | 90.1 | 7.6 | 3.3 | 2.9 | Gr. | Sub. A | Sm. | Al. Br. | Gr. Q. |
| 285 | 71 | 104 | 6.0 | 5.0 | 2.3 | Lip. | Sub. A | Sm. | Br. Ost. | S.S. (Soft) Gr. Q. |
| 284 | 71 | 690 | 14.6 | 7.6 | 4.3 | Tuffuceous Sh. | R. | Sm. | Al. Verm. | Tuffaceous Sh. Gr. Ch. |
| 283 | 177 | 41 | 5.7 | 4.6 | 1.2 | Gr. | R. | Sm. | Al. Br. | Gr. Q. S.S. (Soft) |
| 282 | 110 | 13 | 4.7 | 4.5 | 1.0 | Gr. | R. | Sm. | Al. Br. | Gr. Q. |
| 279 | 155 | 49.5 | 4.0 | 3.75 | 2.5 | Quartzite | R. | Sm. | — | Sh. S.S. (Soft) Tuff. |
| 278 | 99 | 48.6 | 8.5 | 4.2 | 2.0 | Tuff. | R. | Sm. | — | Sh. S.S. |
| 277 | 91 | 86 | 7.0 | 4.0 | 2.8 | Sh. (Soft) | R. | irr. | Br. | S.S. |
| 276 | 77 | 8.5 | 3.4 | 3.4 | 0.8 | S. S. (Soft) | R. | Sm. fl. | Al. | S.S. |
| 275 | 62 | 252 | 10.3 | 6.1 | 2.8 | Gr. | R. | Sm. fl. | Al. Br. | Gr. S.S. (Soft) Sh. (Soft) |
| 274 | 51 | 42 | 4.2 | 2.6 | 1.5 | Lip. | R. | Sm. | Ost. | Gr. S.S.(Tertiary) |
| 273 | 123 | 80 | 5.5 | 3.7 | 3.2 | S. S. (Soft) | R. | Sm. | — | S.S. (Soft) Gr. Sh. |
| 266 | 128 | 58 | 4.5 | 3.7 | 2.5 | S. S. (Soft) | Sub. A | Sm. | Al. Br. | Gr. S.S. (Soft) Tuff. |
| 188 | 214 | 9 | 2.8 | 1.5 | 1.5 | S. S. (Soft) | Sub. A | Sm. | Br. Coral | Lip. S.S. (Soft) Gr. |
| 187 | 128 | 54 | 5.0 | 4.5 | 1.7 | S. S. (Soft) | R. | Sm. | Al. Br. | Tuff. Gr. |
| 376 | 82 | 118 | 6.8 | 4.6 | 3.1 | S. S. | R. | Sm. | Br. | S.S. Sh. Lip. Tuff. |
| 377 | 64 | 211 | 7.2 | 5.4 | 4.3 | Gr. | R. | Sm. | Al. Br. Ost | Sh. S.S. Lip. |
| 380 | 55 | 1.4 | 1.5 | 0.9 | 0.8 | Sh. (Soft) | R. | Sm. | — | S.S. Ch. |
| Senoumi. St. unknown. | — | 32 | 4.8 | 3.7 | 1.3 | Coarse Sandstone | R. | Sm. | Ost | S.S. Sh. Gr. |
| Terrace gravel of C. Onwae | +20 | 18 | 2.2 | 1.6 | 0.4 | Sh. | R. | Sm. | | Ch. Sh. Q. Gr. |
| Terrace gravel of Sagara | +50 | 24 | 2.1 | 1.9 | 1.2 | Gr. | R. | Sm. | — | Ch. Sh. Q. Gr. |

Legend:—

Gr.....Greywackesandstone
Lip.....Liparite
Q.....Quartzite
Pum.....Pumice
S.S.(Soft).....Sandstone(Soft)

R.....Round
Sub-A.....Subangular
fl.....Flat
Sm.....Smooth
Sh.....Shale
irr.....Irregular

Al.....Algae
Br.....Bryozoa
For.....Foraminifera
Verm.....Vermetus
Ost.....Ostrea

*Lithological character of the gravels.*

On the gravels collected, one hundred were arbitrary selected for petrographical study. Hard rocks were prepared for thin section directly, while soft ones were previously soked with canada balsam or bakelite for slicing.

The kinds of rocks discriminated among the gravels under the mineralogical microscope are listed below. (Table III)

Of the hard gravels, there are greywacke sandstone, chert, quartzite, sandstone, and shale closely resembling the rocks either of the Palaeozoic Chichibu System or those of the Mikura Series; these were either directly derived from these series developed along the upper course of the River Ooi, from the conglomerate or gravel bed in the Tertiary or Pleistocene Formations. Especially the gravels of the Palaeozoic rocks in the Pleistocene Formation (upheaved delta formation) developed in the west coast land are closely akin in their character to those found on the Banks.

The gravels of igneous rocks such as biotite-granite, augite-porphyrite and quartz-porphyry were also dredged form the Banks. Besides, there are gravels of green tuffaceous sandstone and fossiliferous calcareous sandstone which seem to have been derived from the Ooigawa Testiary Formation.

In short, the hard gravels are of the geological elements of the west coast region but not of Idu Peninsula where propylite, olivine-bearing two-pyroxene andesite, green tuff, etc. are extensively developed. No gravel of the effusive rock found near Siduoka is present.

Soft gravels are of calcareous sandy shale or calcareous fine sandstone which contain fossil foraminifera such as *Quinqueloculina lamarckiana* d'Orbigny, *Globigerina inflata* d'Orbigny, *Eponides haigenbergii* d'Orbigny, etc. They are closely related to the Miocene rocks developed near Sagara.

In Table III, the rocks of the Palaeozoic, Ooigawa Tertiary, and Sagara Tertiary are discriminated depending on the following characters:—

1) The Palaeozoic rocks are compact and look highly metamorphosed; under microscope, for example, in sandstone, major components are angular quartz, feldspar and pyroxene, and their interspaces are filled with crystals of newly generated biotite and epidote, and minute, likewise newly generated crystals of quartz.

2) The rocks classified as the Ooigawa Tertiary are very coarse grained in appearance, hard but easily crushable by hammer. Under the microscope, they are not metamorphosed, for example, in sandstone, major components of quartz, orthoclase, plagioclase, hornblende, and chlorite are cemented by

Table III. Lithological kinds of the gravels dredged from the Banks and their surroundings, as determined under the microscope.

| Rock \ Locality | | Off Sagara | | Senoumi | | | | | | | | | Nakanose | | | | | | | | | | Off Cape Onmae | | Terrace gravel | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 187 | 188 | 265 | 266 | 273 | 274 | 275 | 276 | 277 | 278 | 279 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | 291 | 376 | 377 | Cape Onmae | Sagara | Zitokata | Megami-yama |
| **Hard gravels** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Older rocks (Palaeozoic or Misaka Series) | Greywacke sandstone | + | + | + | | + | | | | | + | | | | | + | + | | + | | + | | + | + | + | + | | + |
| | Calcareous sandstone | | | | | | + | | | + | | | | | | + | | | | | | | | | | | | |
| | Fine sandstone | | + | + | | | + | | | + | | | + | | | + | + | | + | | | + | | + | | | | |
| | Medium grain sandstone | | | | | | | + | | | | | | | | | | | | | + | | | | | | | |
| | Coarse grain sandstone | | | | | + | + | + | | + | | + | + | | | + | + | + | | | | + | + | | | | | |
| | Sandy shale (slate) | | | | + | + | | + | | | + | | | | | | | + | | | | | | | | + | + | |
| | Chert | | | | | | | | | | + R | | | | | | | + | | | | | | | + | + | + | + |
| | Schalstein | | | | | | | | | | | | | | | | | | + | | | | | | + | | | + |
| | Quartzite | | + | | | | | | | | | | | | | | | | | | | | | | + | + | | |
| Igneous rocks | Quartz porphyly | | | | | | | | | | | | | | | | | | | | | | | + | | | | |
| | Granite | | + | | | | | | | | | | | | | | + | | | | | | | | + | | | |
| | Gabbro | | | | | | | | | | + | | | | | | | | | | | | | | | | | |
| | Diabase | | | | | | | | | | | | | + | | | | | | | | | | | | | | |
| Younger rocks (Ooigawa Tertiary ?) | Augite andesite pumice | | | | | | | | | | | | | | | | | | | | + | | | | | | | |
| | Tuffaceous sandstone | | | | + | | | + | | | | | | | | + | | | | | | | | | | + | | |
| | Fossiliferous sandstone | | | | + | | | | | | | | | | | | | | | | | | | + | | | | |
| **Soft gravels** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Younger rocks (Sagara Tertiary ?) | Fine grain sandstone | | | | | | | | + F | + F | | | | | | | | | | | | | | + | | | | |
| | Medium grain sandstone | | | | | | | | | | | | | | | | | | | | | + | | | | | | |
| | Coarse grain sandstone | | | | + | | | + F | | | | | | | | + | | | | | | | | | | | + | + |
| | Sandy shale | + F | | | | + F | | + F | + F | + F | | | | + F | + | + | | | | + F | | | | | + | | + | |
| **Bed rocks** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (Sagara Tertiary ?) | Conglomeratic coarse sandstone | | | | | | | | | + | | | | | | + | | | | | | | | | | + | | |
| | Sandy shale | + | | + | | + | + | + | + | | + | | + | | | + | + | + | + | + | + | | | | + | + | | |
| | Marly shale | | | | | | + | | | | | | | | | | | | | | | | | | + | | | |
| | Micaceous sandstone | | | | | | | | | | | | | | | | | | | | | | | | | + | | |
| **Others** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Gravels with bore-holes | | + | + | | + | + | + | + (with shell) | | + | + (with shell) | | + | | | | + | | + | + | | + (with shell) | | | | | | |
| Sand-pipe-like concretion | | | | | | | | | | | | | | | | | + | | | + | + | | | | | | | |

A remark: R=fossil radiolaria F=fossil foraminifera

clayey material frequently intermingled with glauconite grains. Especially in calcareous sandstone, shells of pelecypoda, foraminifera, sponge spicules are cemented together with calcite or aragonite, and the cementing materials are sometimes brown coloured owing to ferruginous matter. The same characteristics are exhibited by the rocks of the Ooigawa Tertiary collected in the field.

3) Soft gravels or rock fragments classified as the Sagara Tertiary are either calcareous sandstone or sandy shale, compact but very easily crushable. When observed under the microscope, minute crystal grains of quartz and biotite togather with grains of natural glass, tests of foraminifera are cemented by brownish grey clay. The same are the characteristics of the rocks of the Sagara Testiary in the field.

Among the rock fragments dredged from the stations 277 and 278, there is a pice of conglomeratic sandstone, in which pebbles are of the Palaeozoic rocks and which are hardly distinguishable from a specimen collected from the Tertiary Formation at Sagara. Besides the gravels, sand-pipe-like concretions were dredged from the stations 289, 291 and 287 and carbonized tree trunks covered by clayey ferruginous materials from 6 stations (Table III and VII).

*Sand.*

The sand grains sieved through 2 mm. mesh are divided into 6 classes of 2–1 mm., 1–0.5 mm., 0.5–0.25 mm., 0.25–0.1 mm., 0.1–0.05 mm. and $<0.05$ mm. by means of A.S.K. elutriater and meshes. In general we notice that the size grade of sand grains dose not show any relation to the depth or distance from land, but the sand on the Banks is much coarser than that of the deeper sea floor lying between the submarine platform and the Banks. Table IV and Fig. 3 show the size grades of the sands dredged.

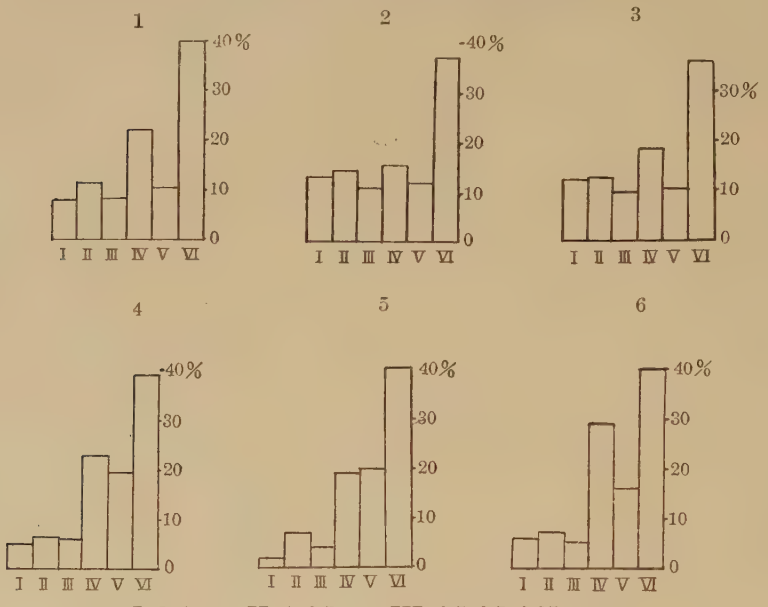
*Shape of sand grains.* The abrade percentages of the sand grains have been calculated by T. Allen's method. The sand grains in a rock of the Sagara Tertiary collected at Cape Onmae show an abrade percentage of 48 percent, the shore sands at Sagara coast that of 75 percent, whereas those on the Banks show that of 64 percent. Thus abrade percentage of the sand grains on the Banks show a value intermediate between the shore sands and the grains in the original rocks, in other words the sand grains on the Banks are more rounded than the original grains but less abraded than those of the shore sand.

*Composition of sands.* Sands consist of fragments of older or younger

Table IV. Size grades of sands dredged from the Banks and their surroundings.

| Station number | Depth in meter | 2—1 mm. | 1—0.5 mm. | 0.5—0.25 mm. | 0.25—0.1 mm. | 0.1—0.05 mm. | <0.05 mm. |
|---|---|---|---|---|---|---|---|
| 377 | 80 | 14.41% | 18.480% | 16.066% | 31.118% | 6.326% | 13.29% |
| 376 | 64 | 20.09 | 29.650 | 15.306 | 16.55 | 6.533 | 11.87 |
| 291 | 77 | 4.94 | 7.284 | 7.143 | 10.88 | 15.471 | 54.29 |
| 290 | 143 | 2.235 | 2.488 | 1.245 | 14.972 | 8.378 | 70.705 |
| 289 | 84 | 10.613 | 6.153 | 6.332 | 14.786 | 18.420 | 43.70 |
| 288 | 77 | 3.935 | 7.693 | 6.285 | 22.468 | 13.968 | 45.651 |
| 287 | 73 | 4.169 | 4.723 | 7.215 | 11.05 | 17.850 | 54.993 |
| 286 | 123 | 22.841 | 18.576 | 8.88 | 28.523 | 4.445 | 16.73 |
| 284 | 71 | 28.980 | 23.33 | 13.41 | 10.96 | 5.44 | 17.88 |
| 283 | 177 | 0.543 | 1.534 | 0.96 | 9.90 | 12.11% | 74.44 |
| 282 | 110 | 19.377 | 29.990 | 16.83 | 16.013 | 3.036 | 15.24 |
| 280 | 273 | — | — | 2.285 | 40.101 | 12.616 | 44.998 |
| 279 | 155 | 9.355 | 20.556 | 22.926 | 19.14 | 4.640 | 23.37 |
| 278 | 79 | 2.110 | 4.226 | 4.886 | 21.244 | 15.932 | 51.11 |
| 277 | 91 | 6.869 | 31.535 | 28.818 | 22.915 | 1.746 | 8.10 |
| 276 | 77 | 2.694 | 4.990 | 5.616 | 21.269 | 10.076 | 55.36 |
| 275 | 62 | 4.778 | 9.533 | 6.587 | 17.905 | 19.005 | 42.12 |
| 274 | 51 | 20.208 | 50.564 | 20.817 | 2.080 | 0.83 | 4.490 |
| 273 | 123 | 3.5186 | 9.301 | 7.214 | 27.314 | 15.190 | 35.490 |
| 266 | 128 | 6.221 | 8.477 | 5.665 | 20.68 | 21.008 | 38.940 |
| 265 | 450 | 5.378 | 8.400 | 5.205 | 32.440 | 11.830 | 36.747 |
| 264 | 280 | 1.286 | 13.092 | 8.076 | 24.611 | 12.292 | 40.647 |
| 263 | 494 | — | — | — | 1.000 | 36.00 | 63.000 |
| 188 | 214 | 17.288 | 8.75 | 5.54 | 43.11 | 8.750 | 26.582 |
| 187 | 128 | — | — | 0.2675 | 20.49 | 28.201 | 50.0447 |

Fig. 3.
Diagrams showing relations between size grade of sand and depth.




I. 2–1 mm, II. 1–0.5 mm, III. 0.5–0.5–0.25 mm,
IV. 0.25–0.1 mm, V. 0.1–0.05 mm, VI. <0.05 mm

1. Average value of the size grade of the sand dredged from 8 stations on Senoumi more than 100 m deep (average 754 m).
2. Average value of the size grade of the sand dredged from 10 stations on Senoumi shallower than 100 m. (average 74.2 m)
3. Average value of the size grade of the sands dredged from 16 stations on Senoumi Bank. (average 110.6 m)
4. Average value of the size grade of the sands dredged from 6 stations outside of Senoumi Bank. (average 282.32 m)
5. Average value of the size grade of the sands dredged from 3 stations in the deep bottom lying between the coastal platform and the Banks. (average 408 m)
6. Average value of the size grade of the sand dredged from 3 stations on the submarine slope of the coast.

sedimentary rock, grains of quartz, feldspar, biotite, pumice, natural glass, shell fragments, spines of echinoid, sponge-spicules, foraminifera, and diatoms. The most abundant of them are rock fragment, next quartz or shell fragment. The 0.5–0.25 mm. grade of the bank sand elutriated with water is almost equal in size of grains to the sand on the coast of Sagara; but the latter shows a white colour owing to the abundance of quartz grains,

Table V. Molluscs from the Banks.

| Station Number | 187 | 188 | 266 | 273 | 274 | 275 | 276 | 277 | 278 | 279 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | 291 | 276 | 277 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth in meter | 128 | 214 | 128 | 123 | 51 | 62 | 77 | 91 | 79 | 255 | 110 | 177 | 71 | 71 | 123 | 73 | 71 | 84 | 143 | 77 | 64 | 82 |
| Pelecypoda | | | | | | | | | | | | | | | | | | | | | | |
| Pecten laqueatus Sowerby | | | | | | | | | | | + | | | | | | | | | | | |
| Chlamys vesiculosa (Dunker) | + | + | | | + | + | | + | + | + | | + | + | + | + | + | + | | | + | + | + |
| Chlamys irregularis (Sowerby) | | | | + | | | | | | | + | + | | | + | | + | | | | | |
| Glycimeris rotunda (Dunker) | + | + | | + | | + | | | | + | | | | | + | | | | + | + | | + |
| Glycimeris pilsbryi (Yokoyama) | + | | | | | + | | | + | | | | | | | | | | | | | |
| Pseudoamsium intuscostatus (Yok) | | | | | | | | | | + | + | | | | | | | | | | | |
| Limopsis crenata A. Adams | | | | | | + | + | + | | + | + | | | | | + | + | | | + | | |
| Limopsis tajimae Sowerby | | | | + | | | | | | + | | | | | | | | | | | | |
| Limopsis cumingi A. Adams | | | | | | + | | | | | | | | | | | | | | + | | |
| Bathyrarca uwaensis (Yokoyama) | | | | | | | | | | | | | | | | | | | | | | |
| Bathyrarca xenophoricola Kuroda | | | | + | | | | | | | | | | | + | | | | + | | | |
| Bathyrarca sp. (St. unknown) | | | | | | | | | | | | | | | | | | | | | | |
| Barbatia reticulata (Gmelin) | + | | | | | | | | + | | + | | | | | + | + | | | | | |
| Lima quantoensis Yokoyama | | | | | | | | | | + | + | | | | | | | | | | + | |
| Diplodonta japonica Pilsbry | | | | | | | | | | | | | | | | | + | | | + | | |
| Pillucina sp. | | | | | | | | | | + | | | | | | | | | | + | | |
| Meiocardia tetragona (Ad et Rve) | | | | | | | + | | + | | | + | | | + | | | | | | | |
| Venericardia ferruginosa Ad et Rve | | | | | | | + | | | + | | | | | | | | | | | | |
| Crassatellites aff. loebbeckei (Kob) | | | | | | | | | + | | | | | | | | | | | + | | |
| Crassatellites sp. | | | + | | | | | | | | | | | | | | | | | | | |
| Saxicava orientalis Yokoyama | | | | | | | | | | + | + | | | | + | | | | + | + | | |
| Pitaria sp. (aff. sulfwrea Pilsbry) | | | | | | + | | | | | | + | | | | | | | | | | |
| Ostrea circumpicta Pilsbry | | | | | | + | | | + | | | | | + | | | + | | | | | |
| Ostrea sp. | | | | | | | | | + | | | | | | | + | + | | | + | + | |
| Ostrea sp. (aff. cochlea Poli?) | | | | | + | + | + | | | | | | | + | | | | | | | + | |
| Corbula substriata Yokoyama | | | | | | | | | | | | | | | | | | | | | + | |
| Solen sp. | | | | | | | | | | | | | | | | | | | | | | |
| Mactra sulcataria Reeve | | | + | | | | | | | | | | | | | | | | | | | |
| Cardita cumingiana Dunker | + | | | | | | | | | | | | | | | | | | | | | |
| Chione isabellina Phil. | | | | | | | | | | + | | | | | | | | | | | | |
| Psamosolen divaricatus (Lischke) var. | | | | | | | | | | | | | | | + | + | | | | | | + |
| Plicatula horrida Dunker | | | | | + | | | | | | | | | | | | | | | + | | |
| Plicatula muricata A. Adams | | | | | | + | | | | | | | | | | | | | | | | |
| Protocardia modestum (Ad et Rve) | | | | | | + | + | | | | | | | | | | | | | | | |
| Chama dunkeri Lischke | | | | | | | | | | | | | | | | | | | | | + | + |
| Volsella nitidus (Reeve) | | | | | | + | | | | | | | | | | | | | | | | |
| Dosinia troscheli Lischke | | | | | | | | | | | | | | | | | | | + | | | |
| Antigona foveolata (Sowerby) | | | | | | | | | | + | | | | | | | | | | | | |

Table VI. Molluscs from the Banks.

| Station Number | 187 | 188 | 266 | 273 | 274 | 275 | 276 | 277 | 278 | 279 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | 291 | 376 | 377 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth in meter | 128 | 214 | 128 | 123 | 51 | 62 | 77 | 91 | 79 | 155 | 110 | 177 | 71 | 71 | 123 | 73 | 77 | 84 | 143 | 77 | 64 | 82 |
| Gastropoda | | | | | | | | | | | | | | | | | | | | | | |
| Ergea walshi Rve | | | | | | + | | | | | + | | | | | | | | | | | |
| Coralliophila lischkeana Dunker | | | | | | | | | | | | | | | | | | | | | | |
| Bursa ranelloides (Reeve) | | | | | | | | | | | | | | | | | | + | | | | |
| Siphonalia mikado Melvill | | | | | | | | | | + | | | | | | | + | | | | | |
| Sphonalia cassidariaeformis Reeve | | | | | | | | | | | | | | + | | | | | | | | |
| Siphonalia aff. spadicea Lischke | | + | | | | | | | | | | | | | | | | | | | | |
| Murex cirosus Hinds | | | | | | | | | | | | | | | | | | | | | | + |
| Murex azami Kuroda | | + | | | | | | | | | | | | | | | | | | | | |
| Ancilla albocallosa Lischke | | | | | | | | | | | | | | | | | | | | | | + |
| Philline sp. | | | | | | | | | | + | | | | | | | | | | | | |
| Calliostoma aff. aculeatum Sowerby | | + | | | | | | | | | | | | | | + | | | | | | |
| Olivella fulgurata Ad. et Rve. | | | | | | | | | | | | | | | | | | | | | + | |
| Olivella sp. | | | | | | | | | | | | | | | | | | | | | + | |
| Erato callosa Ad. et Rve. | | | | | | | | | | | | | | | | | + | + | | | | |
| Erato sp. (St. unknown) | | | | | | | | | | | | | | | | | | | | | | |
| Leptothyra sp. | | | | | | | | | | + | | | | | | | | | + | | | |
| Thyracodes medusae Pilsbry | | | | | | | | | | + | | | | | | | | | | | | |
| Nassarius caelatus (A. Adams) | | | | | | | | | | | | | | | | | | | | | | |
| Nassarius aff. plebecula (Gould) | | | | | | | | | | | | | | | | | | | | | + | |
| Nassarius tateyamaensis Kuroda | | | | | | | | | | | | | | | | | | | | | | + |
| Xenophora pallidula (Reeve) | | | | | | | | | | + | + | | | | | | | | + | | | |
| Fusinus sp. | | + | | + | | | | | | | | | | | | | | | | | | + |
| Ptychatractus aff. coreanicus (Smith) | | | | | | | | | | | + | | | | | | + | | | | | |
| Gyrineum perca Perry | | | | | | | | | | | + | | | | | | | | | | | |
| Solariella angulata Tokunaga | | | | + | | | | | | | | | | | | | | | | | | |

Solariella sp.
Euchelus sp.
Astyris sp.
Turris granosa Hebl
Turis sp.
Phos hirasei Sowerby
Enida japonica A. Adams
Heliacus striamineus Gmelin
Turritella sp.
Triforis otsuensis Yokoyama
Certhium sp.
Certhiopsis sp.
Mangilia ojiensis Tokunaga
Bela? sp.
Cylichnella aff. concinna A. Adams
Cymatium kiiense (Sowerby)
Purpura acanthoptera (Lamark)
Conus cancellatus Lam
Calyptrea yokoyamai Kuroda
Pyramidella sp.
Vexillum hizenensis Pilsbry
Tritonallia eurypteron (Rve)
Tritonallia sp.

Scaphopoda

Dentalium habutae Kuroda et Kikuchi
Dentalium nivosum Kuaoda et Kikuchi
Dentalium rhabdotum Pilsbry
Dentalium octangulatum Donovan
Dentalium lburicatum Sowerby
Dentalium corseum Pilsbry

Pteropoda

Carbolina unicarinata d'Orbigny

while former looks black owing to the prevalence of rock fragments of greywacke sandstone, quartzite, or slate of Palaeozoic System intermingled with numerous minute fragments of soft sandy shale or fine sandstone highly probably derived from the soft rocks of the Sagara Series. Those fragments of soft rocks, when heated, change the colour to red by oxidation. Biotite is common in the shore sand of Sagara as in the Testiary rocks of the same region, but it is rather scarce in the bank sand. It is abundant in the sand dredged from deeper points near the submarine platform as in the station 664, 187, etc. The quantity of organic remains is variable according to positions. Bottom fauna is in general very poor in the bank sand, when compared with that from similar depth in the Sea of Japan. The scarcity of micro-organisms in the sand is a noteworthy fact for the ultilization of the Banks.

*Organisms.*

*Molluscs.* Numerous molluscan remains were found in the bottom samples dredged from 22 stations (19 on the Banks, 4 on the coastal shelf). Of these 1 kind of pteropoda, 6 kinds of scaphopoda, 39 kinds of pelecypode and 48 kinds of gastropoda were classified. Of 39 kinds of pelecypoda, 28 are from the bottoms shallower than 100 m.; and 11 from those deeper. Of 48 kinds of gastropoda, 24 are from the bottoms shallower than 100 m. and the rest from those deeper.

The molluscan fauna is interesting as to the distribution. Of 35 kinds of pelecypoda found in the dredged samples from Senoumi and Nakanose Bank, 18 were common to both Banks, while of 16 kinds of pelecypoda from outside of the Banks, only 3 kinds are not obtained from the Banks. As to the gastropoda; of 29 kinds found on the Banks, only 6 kinds are common to Senoumi and Nakanose. And of 21 kinds dredged from out side of the Banks only 7 kinds were found on the Banks.

As to stated above pelecypoda is less in number of kinds than that of gastropoda, but the former is more numerous the number of individuals and more extended in distribution than the latter over the shallow sea bottom of the Suruga Bay.

Those mollusca belong to neither the tropical nor the shore type, but to the semi-deep sea type, for example, *Pecten vesiculosus* Dkr, *Xenophora pallidula* (Rve), etc. There is no species marketable for food, but from a number of stations, such as 285 (62 m.), 274 (51 m.), 377 (82 m.), etc., living *Ostrea circumpicta* Pilsbry attached on gravels were dredged and

this suggest that the shallower places on the Banks may be utilized for culture of some kinds of shells. The holes bored by boring shells are common on soft gravels or rock fragments dredged from the depths of 70 m. or so, the deepest place from where such bored gravels were obtained being the station 283 (177 m. in depth). Living shells of *jouannetia globosa* Quoy et Gaimard were found in the holes on gravel and rock fragments dredged from 4 stations, 3 in a depth of 70 m. or so. (Table III) and one (st. 286) in a depth of 103 m. On the other hand among living boring shells on gravels and rock fragments lying between the tidal marks along the west coast of the Suruga Bay, I could find no single shell of *jouannetia globosa* Quoy et Gaimard, while we got a beautiful shell of living *jouannetia globosa* bored in the rock fragments from a depth of 82 m. below sea level when dredging the sea bottom off Kominato in Chiba Prefecture in summer of 1933. From these facts it seems to me that this species extends its vertical distribution to a depth of 70 m. below sea level. The occurrence of the gravels attacked by those mollusca on the Banks, therefore, does no means indicate that the gravels or bed rocks sank recently to such a depth after they had been bored by the shells near the shore ine.

Amount of land uplift is sometimes messured by zonally arranged bore-holes of mollusca left on higher parts of sea cliffs which signifys repeated upheavals of the ancient shore line. But considering that some kinds of boring shells such as *jouannetia globosa* Quoy et Gaimard are living in a depth of 70 m. below sea level, we must be observe cautious as to the kind of boring mollusca which can be judged from the nature of hole themselves; on my observation the shape of the hole bored by *jouannetia globosa* is ladle like and easily discriminate from those made by other mollusca.

### *Other organisms*

3 species of deep sea solitary corals were found in bottom samples from 10 stations; species of barnacle was obtained from 3 stations, all deeper than 60 m. It is not known to me whether this barnacle is an inhabitant of such a depth or not.

Calcareous algae were found in the sand dredged from 13 stations, all dead and bleached; 10 of the stations are on the Banks. Of these on the Banks, 7 are less than 100 m. in depth and 3 deeper, the shallowest station being St. No. 275 (62 m.) and the deepest St. No. 283 (177 m.).

The facts that some gravels bored by boring shells were dredged at points deeper than 177 m. and that remains of calcareous algae growing

on gravels were obtained from points deeper than 100 m., may suggest that the Banks were somewhat shallower in the life time of these organisms than now and sank down deeper more lately.

## V. Relation in geology, topography and fauna between the Banks and the land bordering the Suruga Bay.

*Mollusca on the west coast.* For the purpose of studying the relation between the Banks and the coast, I tried to collect mollusca on the coast from Cape Onmae to Kawajiri, where 26 species of pelecypoda and 17 species of gastropoda were obtained. Of these mollusca only 2 species were found in bottom samples from the Banks. I am in doubt whether this difference between the molluscan fauna of the shore and that on the Banks is samples due to insufficiency of collection or at least partly due to the faunal differentiation on both regions.

### *Geology and topography of the west coast land.*

The western border land of the Suruga Bay has geologically and topographically been studied by numerous investigators; namely, the Kakegawa district by Prof. J. Makiyama, the Sagara district by Mr. Y. Chitani, the Ooigawa district by Mr. Y. Otsuka.

The Tertiary Formation forming the foundation of the broad terrace of Makinohara is overlain unconformably by the Pleistocene Series. Igneous rocks are developed only in a small area near Siduoka. The River Ooi and Haginoma run eastward into the Suruga Bay cutting through the terrace.

According to Mr. Chitani's description, the hard shale of the Ooigawa Series (lower Miocene) contain grains of plagioclase, quartz, chlorite, and are the same as those of the gravels dredged from the station No. 377 or a station, definite position unknown on the Senoumi Banks. The Sagara Series consists of sandy shale and conglomerate, which are soft and easily crushable by finger. Their mineral constituents are quartz, plagioclase, biotite, etc. Of many rock specimens collected at Sagara, congomeratic coarse sandstone has the same constituents as the sandstone fragments dredged from the stations No. 277 and No. 262 (Table III). A shale collected at Sagara contain plagioclase, orthoclase, quartz, and biotite as constituents and closely resembles the soft gravels dredged from the Banks.

Table VII. Organic remains from the Banks.

| Station Number | 187 | 188 | 266 | 273 | 274 | 275 | 276 | 277 | 278 | 279 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | 291 | 376 | 377 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth in meter | 188 | 214 | 128 | 123 | 51 | 62 | 77 | 91 | 79 | 155 | 110 | 177 | 71 | 71 | 123 | 73 | 77 | 84 | 143 | 77 | 64 | 82 |
| The dhole bore mollusca on the gravel | + | + | + | + | | + | (with shell) + | | + | (with shell) | | + | | | + | | + | | + | (with shell) + | + | + |
| Jouannetia globosa Quoy et Gaimard | | | | | | + | | | + | | | | | | + | | | | | + | | |
| Pholadidea penita Conrad | | | | | | + | | | | | | | | | | | | | | | | |
| Calcareous algae | + | | + | | | + | + | | | | + | + | + | + | + | + | + | | | + | | + |
| Tree trunk | | | | | | + | + | | + | | + | | | | + | | | | | + | | |
| Echinoid spine | | + | | | | | | | | | | + | | | | | | | | | | |
| Deep sea solitary coral | + | + | | + | | | + | + | | + | + | + | | + | + | | + | | | | | |
| Balanus sp. | | | | | | + | | | | | + | | | | | | | | | | + | |
| Brachiopoda sp. | | | | | | | | | | + | | | | | | | | | | | | |
| Nodosaria raphana (Linne) | | | | | | | | | | + | | | | | | | | | | | | |

Table VIII. Molluscs collected on the west coast of the Suruga Bay.

| Name of species \ Locality | Cape Onmae | Sagara | Jitokata | Kawajiri |
|---|---|---|---|---|
| Pelecypoda | | | | |
| Glycimeris rotunda (Dkr) | + | + | + | |
| Glycimeris yessoensis Sowerby | + | | | |
| Glycimeris albolineata Lischke | + | + | + | |
| Arca subcrenata Lischke | | + | + | + |
| Arca kraussii Philippi | + | | | + |
| Arca navicularis Burg. | | + | | |
| Meretrix meretrix L. | + | + | | |
| Tapes philippinarum Reeve | + | | | |
| Protothaca staminea Conr. | + | + | | |
| Protothaca jedoensis (Lischke) | + | + | | |
| Sunetta excavata Hanley | | + | | |
| Petricola aequistriata Sowerby | + | | | |
| Diplodonta japonica Pilsbry | + | | | |
| Septifer bilocularis pilosus (Reeve) | | | | |
| Septifer excisus Wiegen | | + | | |
| Modiolus barbatus L. | + | | | |
| Venerupis mitis Desh | + | | | |
| Pholadidea penita Conrad | + | | + | |
| Spondylus cruentus Lischke | + | | + | |
| Chama sp. | + | | | |
| Corbula erythrodon Lam. | | + | | |
| Macoma inconqrua Mart. | | + | | |
| Donax proximus Bolten | | + | | |
| Siliqua pulchella Dunker | | + | | |
| Ostrea sp. | | + | + | |
| Anomia sp. | | | | + |
| Macrocallista pacifica Dillwyn | | + | | |
| Barnea (Anchomasa) frgilis (Sow) | | + | | |
| Venus toreuma Gould | + | | | |
| Gastropoda | | | | |
| Siphonalia cassidariaeformis Reeve | + | | | |
| Tonna luteostoma Kiister | + | | | + |
| Turbo cormutus Solander | + | | | |
| Latrunculus japonicus Reeve | + | | | |
| Polinices didyma Boltin | + | | + | |
| Anachis impolita Sow | + | | | |
| Strombus sp. | + | | | |
| Calliostoma unicum Dkr | + | | | |
| Phalium strigatum Gmel. | + | | | |
| Pustularia limacina (Lamark) | + | | | |
| Pustularia helvola (Lamark) | + | | | |
| Erronea notata Gill | + | | | |
| Crepidula aculeata Gmel. | + | + | | |
| Columbella pardalina Lamark | + | | | |
| Conus paupeuculus Sow. | + | | | |
| Cypraea helvola L. | + | | | |
| Tegula pfeifferi Philippi | + | + | | |
| Thais bronni Dunker | + | | + | |
| Umbonium giganteum (Lesson) | | | | + |
| Acmaea saccharina L. | + | | | |
| Hipponyx conicus Schmacher | + | + | + | |

Though the stratigraphical position of in Chitani's sequence is indeterminable, yet the mother rocks of the soft gravels in question, I am sure that the soft gravels found on the Banks have a close relation to the rocks developed in the west coast of the Suruga Bay.

*The geological structure of the Sagara district*

In the Tertiary Formation of the west coast land, the general strike of the strata is NE-SW and main tectonic lines have the same trend. In the area lying east of the line Sagara-Ikesinden there are several valleys running in the same direction. The Senoumi Banks elongated likewise in this directions are suggestive of their tectonic origin, and throw light on the tectonics of the Suruga Bay. Beyond a round depression at the north of the Banks, Kuno-san stands on the west side of the northward prolongation of the Banks. The hill with its highest point (307 m.) close on the steep face along the sea shore has the other sides sloping down very gently to the alluvial land.

It is some 100 m. lower than the average hight of the opposite foot hills of the Akaisi Range; an almost equivalent difference in altitude exists between the Banks with gentle westward and steep eastward slope and the upraised coastal platform of Sagara.

*Geology of Idu Peninsula.*

The following stratigraphical order was determined by self (Table IX) The basal Tertiary Formation is a volcanic complex consisting of green tuff and agglomerate, and propylite flows; the beds strike NW or EW while the main structual lines run rather EW in southern Idu. Those directions are at right angles or oblique of the Banks or the deep trough in the Suruga Bay. A violent volcanic activity occurred in the Pleistocene in Idu Peninsula, and numerous volcanoes still now their conical form more or less well preserve as Mt. Amagi, Daruma, Nekko, etc. Lavas issued from those volcanos are augite-andesites, olivine two-pyronene andesites, and Basalts. The Pleistocene sedimentary strata of northern Idu are composed of materials derived from those volcanic rocks. While none of the gravels dredged from the Banks of Senoumi seems to have been drived from these rocks of Idu peninsula. In southern Idu there is no distinct coastal terrace except a small dissected one at Matsuzaki and at Heda-sinden. In short Idu Peninsula has no relation to the Banks of Senoumi on geology and topography.

Table IX. Stratigraphic sequence of Idu Peninsula.

| | | Formation | Rock | Fossil |
|---|---|---|---|---|
| Quaternary | | PL-Terrace Deposits | Gravel and sand | |
| | | Loam beds | Loam, pumic and loamy sand | |
| | | M, T-Terrate Deposits | Gravel | |
| | | Atami-Group | Complex of volcanic ejectas; locally intercalates shale beds. | Diatom |
| | | (?) | | |
| | | Jô-Group | 1. Tuff and tuffaceous shale.<br>2. Thin alternation of sand, shale and gravel.<br>3. Stratified tuffaceous shale.<br>4. Gravel | Diatom<br>Plant fragments<br>Marine mollusca |
| Tertiary | Shimoda-Series | Matsuzaki-Group | Brecciated andesite-agglomerate and tuff, locally stratified sand. | |
| | | Shirahama-Group | 1. Andesite-agglomerate and tuff (North Idu) Cross-bedding calcareous sandstone (South Idu)<br>2. Liparitic tuff intercalating limestone of limy sandstone. | Shark's teeth<br>Marine mollusca<br>Lepidocyclina<br>Miogypsina |
| | | Tateishi-Group | 1. Stratified tuff, sandstone and shale.<br>2. Lava-flow, agglomerate and tuff of dacite and liparite. | Shark's teeth (rare) |
| | | Aoichi-Group | Andesite-agglomerate with pebbles of hyperthene andesite like bronzite andesite. | Plant fragment |
| | | (?) | | |
| | Yugashima-Series | Yugashima-Group | Alternation of green tuff, green calcareous sandstone and propyrite. | Marine mollusca |

## VI. CONCLUSION.

The banks represent a recently submerged land block which has a close relation in geology as well as topography to the west coast land. The facts that the gravels dredged from the banks consist of the geological elements of the west coast land but none of those of Idu Peninsula that the banks

retained land connection with the west coast land for a long time since the building of the deep trough along the eastern border of the Suruga Bay. It is noteworthy that the banks are arranged on a N-S line, forming the western margin of the deep trough and separated from the west coast land by a shallow sea between. The deep trough is no doubt a significant tectonic line running parallel to the southern part of the Itoigawa-Shizuoka line of Prof. H. Yabe.

The other facts, that remains of calcareous algae were dredged from a depth more than 70 m., and that gravels of soft rocks with bore holes of mollusca were obtained from a point of 177 m. in depth, may suggest a more or less subsidence of the banks in recent age; but as to the latter question more evidence are needed for confirmation.

In conclusion I wish to express my sincere thanks to Prof. Dr. H. Yabe for his kind help and criticism. I am also grateful to Prof. Dr. T. Kato for his kind direction. My thanks are also due to Mr. Marukawa who place the collection of the samples at my disposal and to Mr. Y. Otsuka for his kind guidance in determination of mollusca.

## VII. Literature (* in Japanese)

1. K. Nakajima (1886): Explanatory text of geological map. Sheet "Shizuoka" 1:200.000. Imp. Geol. Surv.
2. K. Nishiwada (1894): On some organic remains from Tertiary lime stone near Sagara, Totomi. Jour. Coll. Sci. Imp. Univ. Tokyo, vol. VII.
* 3. T. Iki (1909): Preliminary note on the geological survey of oil field in Tôtomi. Rep. of Imp. Geol. Surv. No. 13.
* 4. N. Yamazaki (1905): On the topography of the coastal plane, Totomi. Jour. Geol. Soc. Tokyo. vol. 12 No. 137.
* 5. Yode (1911): On the current of Senoumi in the Suruga Bay. Jour. Geography, vol. 22, No. 261.
* 6. H. Yabe (1911): Tectonic line between Itoigawa and Shizuoka, Gendainokagaku, vol. VI, No. 3.
7. M. Yokoyama (1923): Tertiary mollusca from Dainichi in Totomi. Jour. Coll. Sci. Imp. Univ. Tokyo, vol. XLV, St. 2.
* 8. J. Makiyama (1925): Tertiary stratigraphy of Kakegawa district in Shizuoka prefecture. The glove, vol. 3, No. 6.
9. M. Yokoyama (1926): Testiary mollusca from southern Totomi. Jour. Fac. Sci. Imp. Univ. Tokyo, Sect. II, Vol. 1, part 9.
10. T. Tokuda (1926): On the echelon structure of Japanese archipelago. Jap. Jour. of Geol. and geogr. vol. 5, No. 112.
*11. Y. Chitani (1926): The Tertiary in the vicinity of Kakegawa and Sagara, Totomi. Jour. Geogr. vol. 38, No. 444.
12. J. Makiyama (1927): Molluscan fauna of the lower part of Kakegawa Series.

Mem. coll. Sci. Kyoto Imp. Univ. Ser. B. III, part 1.

*13. T. OKAYAMA (1921): On summit level of Akaishi range. Geogr. Review of Japan. vol. 4, No. 8.

*14. J. MAKIYAMA (1928): Geology of Kakegawa district in Shizuoka prefecture. The Globe, vol. 9, No. 1, 2.

*15. Y. CHITANI (1929): Expl. Text. Geol. Map. Japan "Sagara" Sheet. 1:75,000. Imp. Geol. Surv.

*16. A. WATANABE (1929): Some consideration concerning the Japanese raised delta. Geogr. Rev., Japan, vol. 5, No. 1.

*17. T. TSUJIMURA (1929): Nippon Chikeishi.

18. H. YABE (1929): The latest land connection of Japanese island to Asiatic continent. Proc. of Imp. Acad. V. No. 4.

19. H. YABE and TAYAMA (1929): On some remarkable examples of drawned valley found around Japanese Island. Record of the oceanographical work in Japan. II. 1.

*20. A. WATANABE (1930): On the development of topography of the southern Akaishi range and its history. Geogr. Rev. Japan, vol. 6, No. 7.

*21. Y. OTSUKA (1930): An opinion on H. Yabe's paper "Geological age of the latest continental stage of Japanese island to Asiatic Continent." Jour. Geol. Soc. Tokyo, vol. 37, No. 439.

*22. Y. OTSUKA (1930): Stratigraphy of nothern part of Miura Peninsula, with special reference to the change of the shore line at south Kanagawa prefecture in the latest geological age. Jour. Geol. Soc. Tokyo, vol. 37, No. 442.

23. J. MAKIYAMA (1931): Stratigraphy of the Kakegawa pliocene in Totomi. Mem. Col. of Sci. Kyoto Imp. Univ. Ser. B, vol. III, No. 1.

24. A. IMAMURA (1928): On the seismic activity of the Kanto district. Jap. Jour. Astronomy and geophysics, vol. V, No. 3.

*25. Y. CHITANI (1930): On the geology of the Sagara oil field in prefecture of Shizuoka. Jour. Geol. Soc. Tokyo, vol. XXXVII, Supplement No. 477, Sect. 20.

*26. Y. CHITANI (1932): Explanately text of geological map sheet "Shizuoka." 1:75,000. Imp. Geol. Surv.

27. Y. OTSUKA (1931): On the shiftings of coast line in the Diluvium of Japanese Island and the geological age of drawned valley develope in the continental shelf. Geogr. Rev. Japan, vol. 7, No. 6.

*28. Y. OTSUKA (1931): Quarternary, Iwanomikoza.

29. Y. OTSUKA (1931): Early pliocene crustal movement in the outer zone of southwest Japan and in Nauman's fossa magna. Bull. earthq. Res. Inst. 9 (1931), 340–352.

*30. R. TAYAMA (1931): Relation between geological structure and North Izu earthquake. Science report of the Saito gratitude foundation, No. 11.

31. R. TAYAMA and H. NIINO(1931): Outline of the geology of Izu Peninsula. Annual report of the work No. 7. The Saito gratitude foundation.

32. ALLEN C. TESTER (1931): The measurement of the shapes of rock particles. Jour. of sedimentary petrology, vol. 1, No. 1.

*33. Y. OTSUKA (1932): Cycle of sedimentation in Japanese Island. Geogr. Rev. Japan, vol. VIII, No. 12.

34. Y. OTSUKA (1932): Post pliocene crustal movement in the outer zone of southwest

Japan and in the "fossamagna" (I). Bull. of Earth. Research Inst. Tokyo Imp. Univ. vol. X, part 3.

*35. K. Okamura (1932): Geological distribution of plants in the sea. Iwanamikoza.

36. S. Nomura and H. Niino (1932): Fossil mollusca from Izu and Hakone. Science reports of Tohoku Imp. Univ. 2nd Ser. (Geology), vol. XV, No. 3.

*37. H. Niino (1932): Sand-pipe like concretions found at sea-bottom around Japanese islands. Jour. of geography, vol. XLV, No. 528.

*38. N. Niino (1933): On the soundings from Yamato-tai in the sea of Japan. Jour. Geol. Soc. Tokyo, vol. XL, No. 473.

*39. H. Niino (1933): Distribution of gravels at sea-bottom around the Japanese Islands. Jour. of geography, vol. XLV, No. 533.

*40. H. Hisano (1933): Geology of the northern district of Izu Peninsula. Jour. Geol. Soc. Tokyo, vol. XL, No. 477.

41. S. Yamaguchi (1933): Some consideration on the shore profile. The geographical review of Japan, vol. XI, No. 6.

*42. Y. Konno and Y. Otsuka (1933): Stratigraphy between the river Ooi and the river Fuji in Shizuoka prefecture. Jour. of Geol. Soc. Tokyo, vol. XV, No. 475.

*43. Y. Otsuka (1933): The Japanese coast line. Geogr. Rev. Japan, vol. XI, No. 10.

44. I. Amemiya and Y. Oshima (1933): Note on the habit of rock boring molluscs on the coast of central Japan. Proc. of Imp. Acad. vol. IX, No. 3.

*44. I. Amemiya and Y. Oshima (1933): Note in the habit of rock boring molluscs. Botany or Zoology for scientific and applied, vol. 1, No. 9.

45. Y. Otsuka (1933): The geomorphology and geology of northern Idu Peninsula, the earthquake fissure of Nov. 26, 1930, and the pre- and post-seismic crust deformations. Bull. Earthq. Res. Inst. Tokyo, Imp. Univ. vol. XI (1933), Part 3.

46. H. Nagaoka and T. Shirata (1933): Formation of fossamagna and Japanese alps on the fissure line of central Japan. Proc. Imp. Acad., vol. IX, No. 8.

## Plate 34

(Photo. by Yoshi K. Okada)

Fig. 1. *Jouannetia globsa* Quoy et Gaimard in the rock fragments dredged from station 278.

Fig. 2. Gravels and a rock fragment of soft tuffaceous sandstone bored by mossulca, station 275.

Fig. 3. Gravels of fossiliferous fine sandstone (Ooigawa Tertiary) bored by boring mollusca.

Fig 1

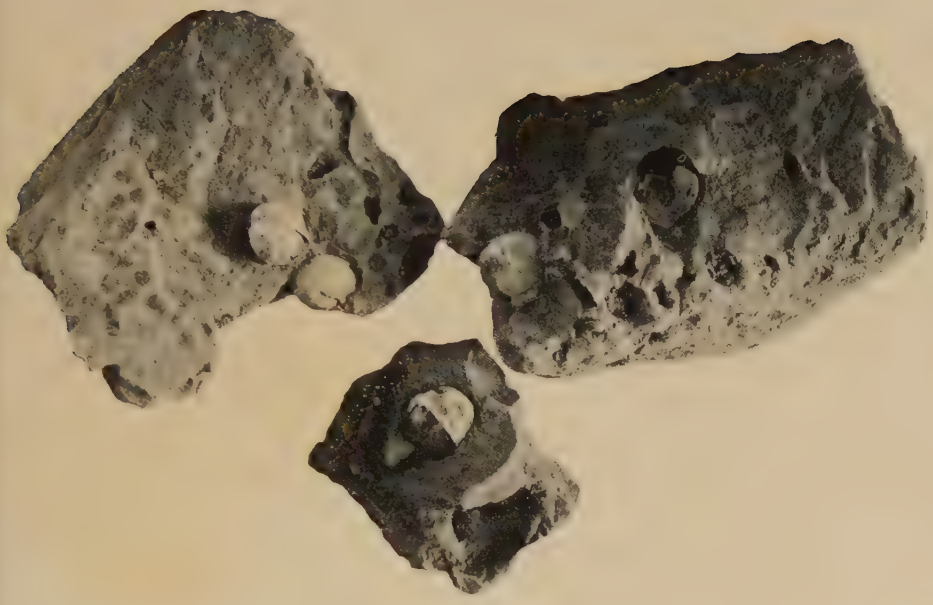



Fig.3

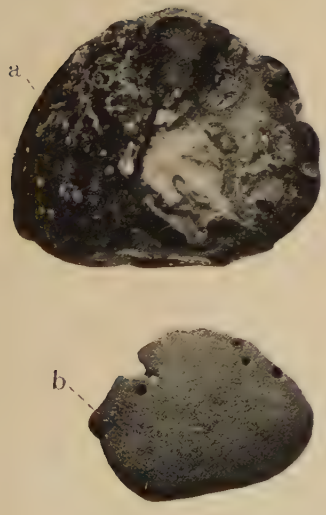
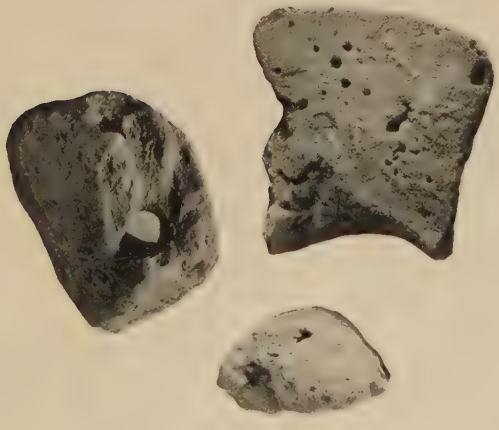



Fig.2



## Plate 35

(Photo. by Yoshi. K. Okada)

Fig. 1. Microphotograph of a gravel of fossiliferous sandstone dredged from station 377. (Rock of *Ooigawa Tertiary*) ×40.

Fig. 2. Sand-pipe-like concretion and gravels dredged from station 291.
a.....Gravels of greywacke sandstone.
b.....Sandpipe-like concretion.

Fig. 3. Gravels encrusted by calcareous algae dredged from station 287.
a.....Cross section of a gravel of greywacke sandstone.
b.....Exterior feature of a gravel.
c.....Gravels of fine tuffaceous sandstone (Sagara Tertiary?)
d.....Gravels of greywacke sandstone.

Fig. 4. Carbonized wood stems coated by clay, dredged from station 289.

Fig 1
×40
a
Fig.2
b
Fig.3
b
a
c
d
Fig.4
a
b
0 1 2 3 4 5cm

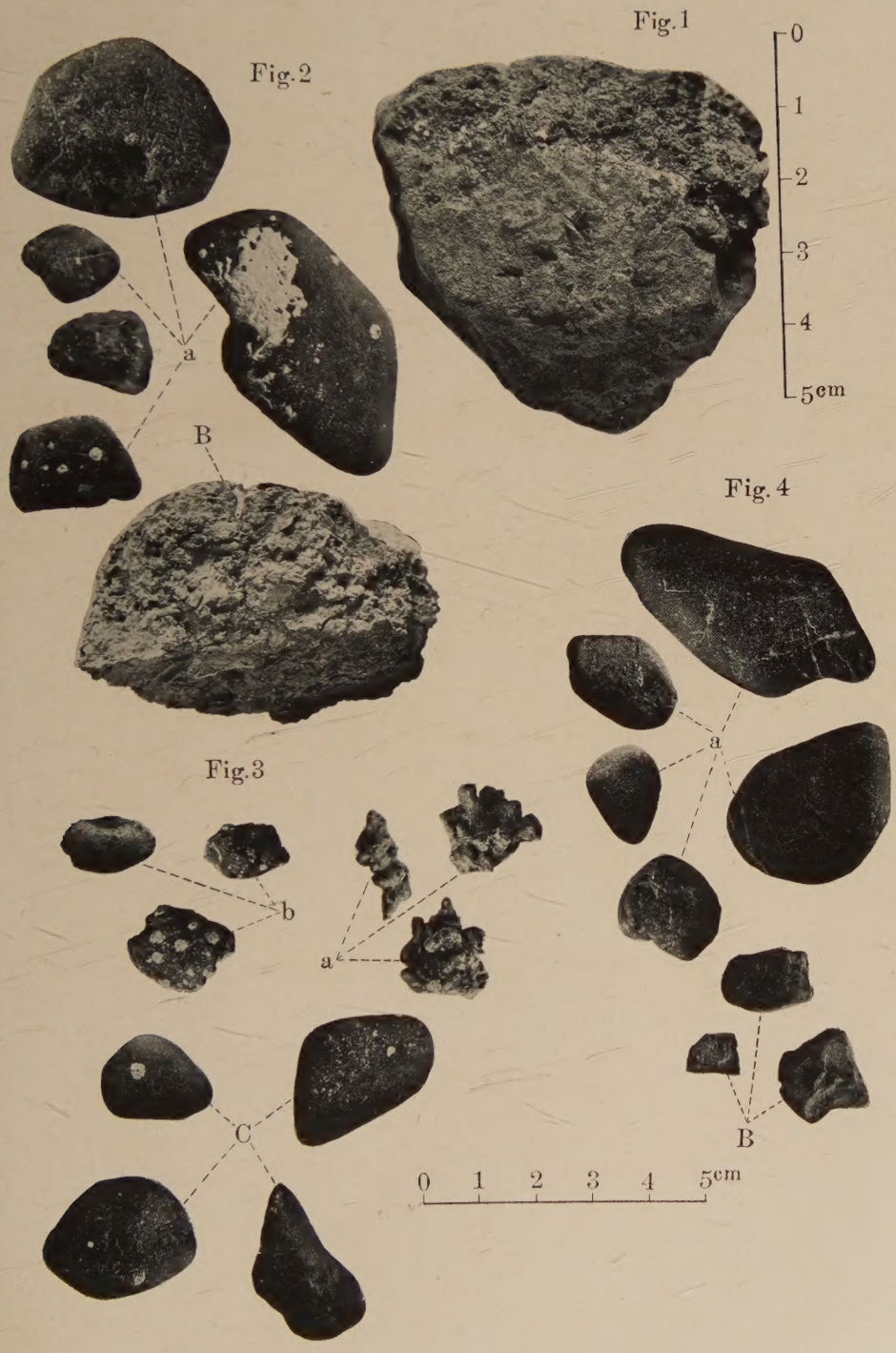


Fig.1
Fig.2
Fig.3
Fig.4
0
1
2
3
4
5cm
a
B
b
C
0 1 2 3 4 5cm

# INDEX to Vol. XXIX.

* Pages Illustrated


Page

Antimony Electrode .....29, 31*
Banks of Senoumi .....69, 71
Boring Shell .....83
Canned Food .....1
Canned tuna in Oils .....1
Cottonseed Oil .....2~14
Electrode .....29
Electrode Potential .....32, 34, 37
Fauna, of the Suruga Bay .....84
*Gelidium* (Pl. 16~28, 31, 32).....47, 49
„ *Amansii* f. *elatum* n. f. (Pl. 21) 56
„ „ f. *elegans* n. f. (Pl. 20, 31) .....56
„ „ f. *teretiusculum* n. f. (Pl. 22, 31) .....56
„ „ LMX. (Pl. 19~22, 31).. 52, 55
„ *australe* J. AG. .....54
„ *clavatum* sp. nov. (Pl. 28, 32)...61
„ *crinale* (TURN.) LMX. (Pl. 16)..50
„ *decumbensum* sp. nov. (Pl. 27, 32) .....60
„ *divaricatum* MART. (Pl. 16) ....50
„ *elegans* KÜTZ. .....54
„ *japonicum* (HARV.) OKAM. (Pl. 18) 52
„ *linoides* KÜTZ. (Pl. 26, 32) .....59
„ *pacificum* OKAM. (Pl. 16) .....51
„ *pucillum* f. *foliaceum* n. f. (Pl. 17) .....51
„ „ (STACKH.) LE JOL. (Pl. 17, 31) .....50
„ „ var. *conchicola* PICC. et GRUN. (Pl. 17) .....51
„ *subcostatum* OKAM. (Pl. 18) ....52
„ *subfastigiatum* sp. nov. (Pl. 24, 32) .....57
„ *tenue* sp. nov. (Pl. 23, 31) .....56
„ *vagum* sp. nov. (Pl. 25, 32) .....58

Page

Gravels .....72
Idu Peninsula, Geology of .....87
*Jouannetia globosa* Quoy et Gaimard ...83
Kanesunose, Bank of .....69, 72
Lithological charactor, of Gravels .....74
Molluscs .....82, 84
Nakanose, Bank of .....69, 72
Oils .....1
„ , heating, storing & mixing of ....2, 6
„ , Acid values & iodine values of ..2, 10
Olive Oil .....2~14
Ooigawa Series .....76, 84
Organisms, of the Suruga Bay .....82
pH .....29
pH, Determination of .....29
*Pterocladia* (Pl. 29, 30, 33) .....47, 61
„ *densa* sp. nov. (Pl. 30, 33) .....63
„ *nana* OKAM. (Pl. 33) .....64
„ *tenuis* sp. nov. (Pl. 29, 30, 33)..62
Sagami Bay .....15*
Sagara district, geological structure of..87
Sagara Series .....76, 84
Sand .....76
„ , composition of .....76
„ grains, shape of .....76
Senoumi, Bank of .....69, 71
Soundings, of the Suruga Bay .....69
Soya bean Oil .....2~14
Stick Antimony Electrode .....29, 31*
Suruga Bay .....69, 71
Tidal Oscillations (Pl. 1~15) .....15
Topography, of the Suruga Bay .....84
Tuna .....2~14
Water Movement, of the Sea (Pl. 1~15) .15